the Petroleum Engineer

FOR MANAGEMENT

INTEGRATED EDITION OF THE PETROLEUM ENGINEER

Operations Research

Brainstorming — What It Is

Executives "Made to Measure"

How Do You Solve That Overtime Question?

making

extra footage

for rock bits

The "white hot" metal being alloyed here at over 5000°F., is molten *Hughesite* — one of the hardest known man-made materials. It is 25 times more wear-resistant than hardened steel. *Hughesite* is an exclusive Hughes development. Hughes' methods of applying *Hughesite* to bit teeth and gauge surfaces are increasing the rate of penetration and footage drilled per bit. Here is another example of HUGHES' continuing effort to provide the drilling industry with the best possible tools.

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AUGUST 1957

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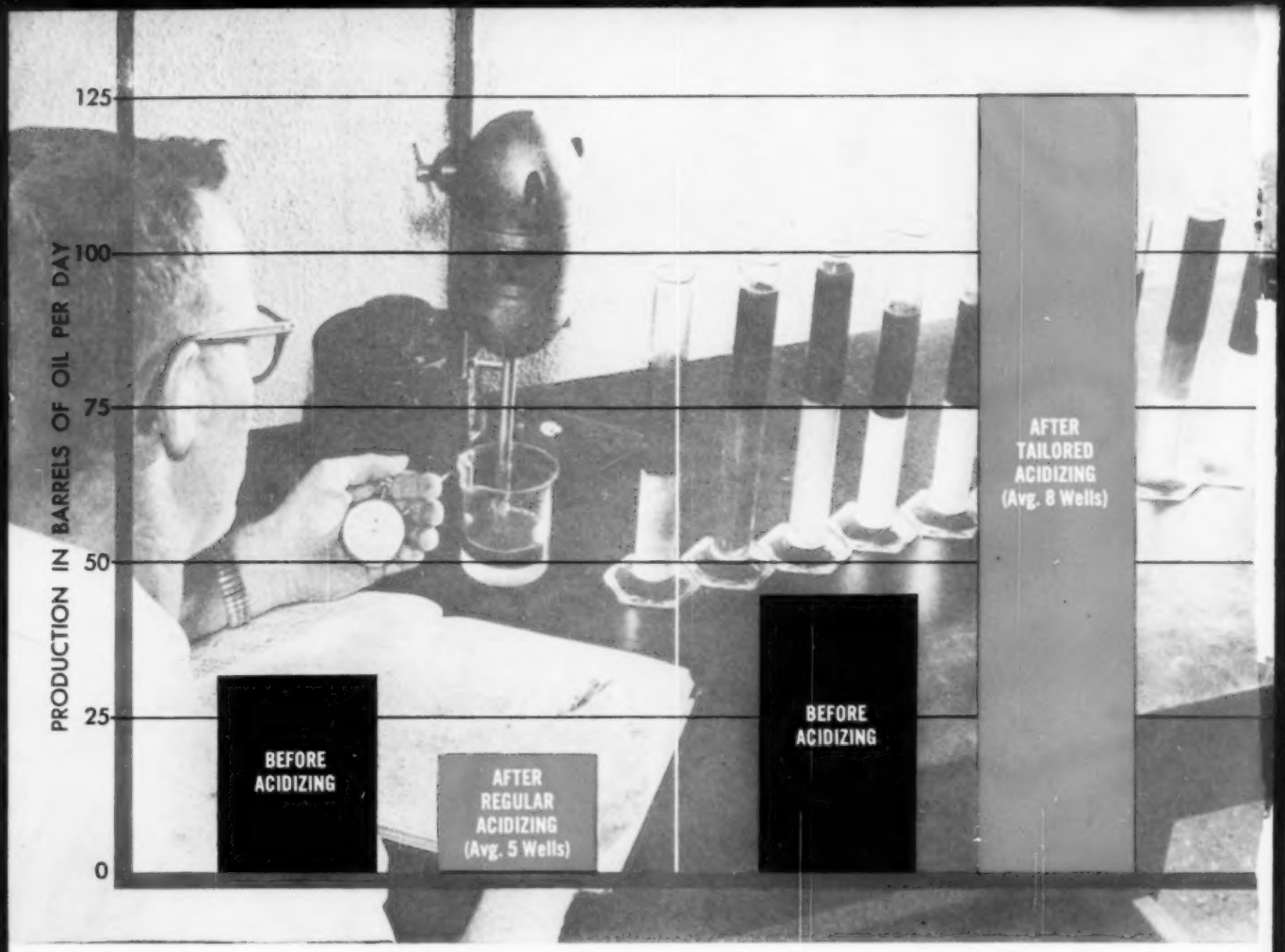

"BLIND" ACIDIZING CAN BACKFIRE

Case In Point: McClosky Limestone

This formation tested 93 to 99 per cent soluble in acid, yet regular acid treatments often reduced, rather than increased, production. The obvious conclusion was emulsion block, but ordinary emulsion breakers were not effective.

Dowell engineers obtained cores and formation fluid for laboratory investigation. The result: it was discovered that an unusual emulsion was being formed during acidizing. The laboratory recommended a special addition agent which was mixed with the acid to prevent emulsion. Immediately, results of treatments with this Dowell "tailored acid" became consistently successful, as the bar charts show.

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Tensile	135,000
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Reduction in Area	57%
Izod Impact	85
Brinell Hardness	277 T

Chemical Properties	Typical
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Manganese	.70
Phosphorus	.03
Sulphur	.03
Silicon	.27
Nickel	1.82
Chromium	.80
Molybdenum	.25

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the Petroleum Engineer

FOR MANAGEMENT

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I love fools' experiments. I am always making them.
— *Charles Robert Darwin*

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It costs $200,000 to replace a man in middle management . . . a top executive comes higher . . . to find the right man, the executive should be made to measure.
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HARDLY ANYBODY UNDERSTANDS IT

Once upon a time there was a grocer. He bought stock for his store and then sold it for enough to pay for the groceries, his rent, taxes, his helpers and himself.

He sold all the groceries that were on his shelves so he sent an order to a company and money to pay for a carload of groceries. The company kept the money but didn't send him any groceries.

He took the loss off his income tax but he couldn't get his money back. Anyway, he had to have groceries to stay in business. So he tried another company and the same thing happened — and another and another. Finally the ninth one sent him three carloads of groceries for the price of one.

The grocer thought, "I've heard of people who got nine carloads for the price of one but this isn't a very stable business. I believe I'll get out of it."

That's a wild story but it resembles pretty well a wildcatter's experience. He buys his stock-in-trade from Mother Earth and she's a whimsical dealer — generous and stingy by turns.

Now the oil finder is just as smart as the grocer who had unreliable suppliers. He'd have quit his business and found himself another if Uncle Sam hadn't said, "This nation needs oil and if you'll take the risks and pay the costs to find it, you won't have to pay me income tax on part of the oil you do find and produce."

This is called the "27½ percentage depletion allowance."

Hardly anybody understands it. If you are a producer of oil and gas, you have a good idea of how it works. At least you know you probably wouldn't be in business without it.

It can be explained but it isn't easy. We can't describe what our nation would be like without it because, fortunately, enough Congressmen have understood its vital need to keep the percentage depletion deduction in effect since 1926.

You don't have to understand it to know that it worked.

It put the explorers and producers back in business. It provided enough oil and gas to make us the most energized nation in history.

Some persons call it a billion-dollar tax loophole. Without depletion allowance taxes would certainly go up. (And would be passed on to the consumer, who always somehow ends up paying the ticket for taxes.) Wildcatters would begin looking for grocery stores and more dependable suppliers than our little grocer had. Before long production and reserves would be down and Uncle Sam would be collecting *less* instead of more taxes from the industry.

So when you hear the story of how percentage depletion is a billion-dollar tax loophole for the petroleum industry, remember the story of the harassed grocer. They are both fairy tales.

Ernestine Adams

Congrats and $25 to W. S. Herron, Jr., Norman, Okla., for this quip.

"..he wants to borrow our separator"

Night is just another work "day" at the big Lone Star Steel plant. The beehive of activity and the red glow of molten steel are Joe Roughneck's assurances that we are making API casing, tubing and line pipe at full capacity.

Joe Roughneck (heart of the oil and gas industry) knows that all Lone Star pipe is quality checked repeatedly . . . and *fully normalized*. What's more, Joe knows that our new open hearth furnace and new stretch-reducing mill are growing toward completion at full speed. One day there'll be more Lone Star API quality pipe.

Neighbor, wherever you are, specify Lone Star and we both get a good deal.

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THIS INDEX IS PROVIDED AS AN ADDITIONAL SERVICE FOR OUR READERS—THE PUBLISHER ASSUMES NO RESPONSIBILITY FOR ERRORS OR OMISSIONS

They're gas-lifting oil from three wells

with this Direct-Connected Compressor Unit

In this installation, the forced-draft horizontal cooler consists of two compartments. Directly over the fan is an air-fin-type intercooler for the gas, and above that is the radiator for water-cooling the engine and compressors.

In the Oxnard, California field, gross production of 254 barrels per day is secured from three wells of 6900′, 7000′, and 9100′ depths with this "Oilwell" DGE 200-hp Compressor Unit. The separator gas at 60 lbs. pressure is boosted to 950 lbs. and returned to the system. At 300 rpm this two-stage compressor is circulating approximately one million cubic feet of gas per day.

This unit consists of two slow-speed, horizontal type compressors, positioned side by side and driven through right-angle, spiral-bevel gears by a single prime mover—all mounted on a common skid base, including up-draft radiator and fan assembly. Separators were also installed on this common base at the customer's request.

Let an "Oilwell" Engineer help you select the compressor best suited for your next application. Our range of sizes from 20 up to 300 hp provides a wide choice.

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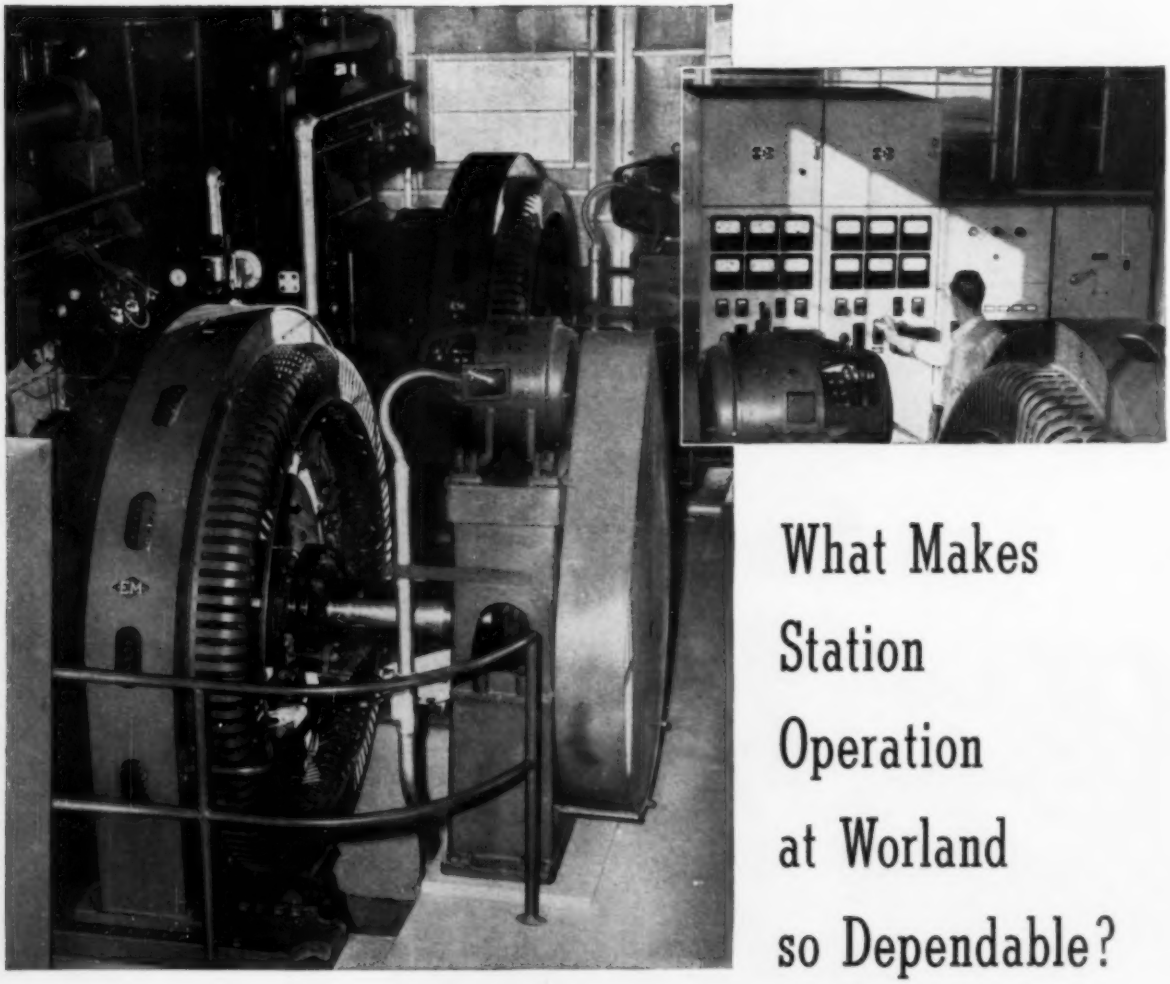


What Makes Station Operation at Worland so Dependable?

● Reliability is a big word in the Montana-Dakota Utilities Co. gas compressor station at Worland, Wyoming, designed, engineered and built by Stearns-Rogers Mfg. Company of Denver. You find it "built-in" in every phase of this pipe line station's activities . . . from the main compressing operation to station lighting and auxiliaries such as cooling fans, water circulating pumps, water well pumps and other units.

Worland station's electric power generators have received the same intensive design and engineering as the major compressors. Engines have been selected carefully, and E-M Engine-Type Synchronous Generators were specified as the most dependable source of station power, 24 hours a day. These generators, rated at 463 kva, 370 kw, 0.8 power factor, 327 rpm, 480 volt, 3 phase, 60 cycle, provide all station power for plant motors and lighting. E-M Switchgear at Worland includes two generator panels and a distribution panel.

You'll find E-M Generators and pre-engineered Switchgear unusually well-suited for pipe line service. A special E-M insulation treatment protects generator coils against corrosive vapors. Big motors can be started with minimum voltage dip. Parallel operation is smooth and flickerless. And E-M design simplicity plus careful attention to full strength in the smallest details assures years of dependable operation at low cost.

Keep in mind E-M's specialized experience on pipe line power generation equipment of various types. Ask your nearest E-M sales engineer for information, and write the factory for E-M Synchronizer No. 35.

ELECTRIC MACHINERY MFG. CO.
MINNEAPOLIS 13, MINNESOTA

2200-TPA-2138

E-M

Specialists in Generator and Switchgear Engineering

How much will it lift?

With this Koehring 405 crane, you're equipped to lift any load up to 20 tons. That's based on conservative 75% rating. Boom lengths range from 40 to 90 feet. Butt-connected boom is safe, solid. Inserts are easily changed. When extra reach is needed, 15 to 30-foot jib can be added to 80-foot boom. This gives you a maximum boom and jib of 110 feet.

Lift capacity is work capacity

Power, strength and load stability as a crane increase the 405's *work capacity* with every attachment. It handles 1 to 1½-yard clamshell or dragline buckets on a wide work radius — readily converts to heavy-duty 1-yard shovel or hoe.

When it comes to operating ease, the 405 is in a class by itself! Has self-adjusting power clutch, light lever-pull, sensitive "feel" of load, automatic crawler traction brakes, only 2 main shafts in upper machinery, and many other advantages which simplify operation, reduce maintenance, and help you get more work done. Let your Koehring distributor show you what the 405 will do for you. Better call him *today*.

◀ **45-TON "ROUSTABOUT" — Installing heavy machinery in the oil field, the new Koehring 445 truck crane shows off its muscles. Heaviest lift was a 23-ton mud pump — an easy lift for the husky 445. It can pick up 45 tons with 40-foot boom at 15-foot radius. On high lifts it handles max. 120-foot boom, plus 30-ft. jib.**

KOEHRING
DIVISION OF KOEHRING CO.
Milwaukee, Wisconsin

K7001

THE CONFERENCE TABLE

I love fool's experiments. I am always making them. – CHARLES ROBERT DARWIN

How Automation Grows

Our third annual Instruments and Control Equipment Directory for the Petroleum Industry will be published in next month's issue. It is really amazing how the interest and use of instruments of this type has assumed so much importance in our modern industry. Manufacturers of this type of equipment have increased also. Our directory has grown in size in the last three years.

This material is published in connection with the Instrument Society of America's 12th Annual Instrument-Automation Conference and Exhibit. This is held at the Cleveland (Ohio) Auditorium, September 9-13. J. T. Vollbrecht, ISA president of Energy Control Company, looks for attendance to top last year's 30,500 spectators. They came from every state in the United States and some 22 foreign countries. Membership of the ISA now numbers more than 10,000.

Several new features have been added to the conference. The systems workshop and the computers application clinic are two top attractions. Both should draw attendance from the petroleum industry.

Mail Logistics

The Associated Press recently challenged the bureaucrats to explain this one: Dayton, Ohio: (AP) Here's one for those who like to ponder the devious ways of bureaucracy:

On a Dayton street corner stand two mail boxes, one sternly labeled "out of town mail" the other "local mail."

Three times daily a mail truck pulls up and the driver casually empties both boxes into the same bag.

Tariff Aid for Minerals

First indication that the administration had in mind some limitations on imports came last February when Interior Assistant Secretary Felix E. Wormser spoke at the AIME meeting in New Orleans. He told the meeting that the government is "concerned lest American investment capital find it increasingly profitable to go into mining abroad at the expense of American development."

He noted that tariffs are "intended to provide a reasonable balance between domestic production and imports so that an operator may invest his time, effort, and money in a long-term development of domestic resources with some confidence that the rug will not suddenly be pulled out from under him by a surge of new imports."

The Assistant Secretary said, "we also run into serious problems when oil, lead, zinc, copper, and other commodities produced by American operators aboard seek their principal markets in the U. S. in competition with domestic production."

Giveaway-itis

Eugene W. Castle, in his book "The Great Giveaway" (Henry Regnery Company, Chicago, Illinois; price $3.50) gives under one cover a history of foreign aid. "During the last two decades," he says, "Uncle Sam has actually given a loan to other nations the stupendous sum of $108,847,770,000 AND he is still giving."

Whether you are for or against aid to foreign countries, it is a good thing to know how much your country has paid out to encourage economic recovery, to aid in military strength, and sometimes for reasons that are not quite clear.

Also, Mr. Castle goes into people-to-people aid, which is in addition to the government help. He reports a conservative estimate of over 2500 private groups and agencies engaged in some kind of program of foreign assistance. CARE, for instance, has delivered more than 15 million person-to-person remittances and packages to individuals in 50 countries.

If you want to make up your mind about your government's foreign aid you should read "The Great Giveaway." Although Mr. Castle concludes that it is time to slow down, he does not wholly condemn the giving that has been done, and he certainly presents a factual picture of both government and private foreign aid.

Unions Stick Together

Although companies are the ones subject to anti-monopoly statutes, corporations are not as quick to back up each other as are unions.

General Electric in April released a vigorous protest concerning public expressions of union president, James B. Carey. Under the title "The Predictable Mr. Carey" the GE public and employee relations news refuted a number of statements Carey had made to the press.

In early May the Oil Chemical and Atomic Union News had a short article saying Carey was "belabored for hitting at GE sales representatives using calls girls in Newark, New Jersey." A larger article was headed "Brainwashing May Become GE's Most Important Product."

The article reported on a plan mapped out for GE's public and employee relations, purpose of which is to begin "an active campaign turning public attitudes away from the left." The union paper states "General Electric's plan would set up an elaborate system of carrying out the brainwash program ... it ought to work on over-worked business men in the same way it worked on young men in prison."

Innuendo aside, the GE public relations plan appears sound even as told by the Union News. Fundamentally, the many who wrote the article believes in about the same things that GE does.

A Sad Story

As I sat musing,
Alone and melancholy and without a friend,
There came a voice
Out of the gloom
Saying, "Cheer up; things might be worse!"
So ... I cheered up, and
Sure enough — things got worse.

Careful Researchers

Seven Research and Development divisions of oil companies went through 1956 without an injury according to statistics prepared by National Safety Council. These seven were Phillips at Bartlesville, Oklahoma; Stanolind (Pan American), Tulsa; Carter Oil, Tulsa; Core Laboratories, Dallas; United Gas Pipe Line, Shreveport; Lion Oil Company, El Dorado, Arkansas; Cities Service. Socony Mobil, New York's research laboratories received a certificate of achievement for reducing injury frequency rate. For all reporting, the frequency rating was reduced by 8 percent.

Excellently Managed Companies

Manual of Excellent Management, 1957, published by American Institute of Management (125 E. 38th Street, New York 16, New York, price $16.00), has recently been released. The list includes all companies which have had a management audit during the year. In each case are given: Name of the company, its business, number of employees, its address, names of its officers, its rating, and the length of time it has been listed.

Petroleum companies and natural gas companies listed as having passed the audit are: Amerada, Atlantic Refining, Cities Service, Continental Oil, Creole Petroleum, El Paso Natural Gas Company, Gulf Oil, Humble Oil and Refining, Lone Star Gas Company, Louisiana Land and Exploration, Newmont Mining, Ohio Oil, Oklahoma Natural Gas, Panhandle Eastern Pipe Line, Phillips Petroleum, Seaboard Oil, Shamrock Oil and Gas, Shell Oil, Socony Mobil, Standard Oil (Indiana), Standard Oil (Ohio), Standard Oil of California, Sun Oil, Texas Company, and United States Smelting Refining and Mining Company.

Protest TVA Engineering Service

A broad grant of authority in a proposed TVA revenue bond bill to allow TVA to render engineering services for others, was protested by the National Society of Professional Engineers.

Testimony opposed a clause in a Senate bill (S. 1869) to authorize TVA to perform engineering services in connection with the construction of any facilities in which TVA has any interest whatsoever.

The NSPE representative told a Senate subcommittee the Federal Government "should not compete with its own citizens in the furnishing of materials or services to nonfederal agencies or persons, except under the most extreme or emergency conditions."

Patents Are Important, Too

Richard Spencer, former first assistant U. S. commissioner of patents, wrote an editorial in the Saturday Evening Post for May 25, 1957, that should be read by every business manager. It is the first editorial on page 10 entitled "Let's Give the Investor a Break on His Patents." Mr. Spencer feels that the attacks by the Justice Department on American business firms with large patent holdings have affected the inventive mind. He says we lag behind in the production of new machines and processes — that hope of personal reward has been taken out of technical research and discovery.

Whom Are We Fighting?

Everybody who talks about public relations comes up with a general term like "*our critics* exploits this" or "the industry is attacked by *liberal forces*." Our detractors are so vaguely seen that we scarcely know which way to look for them. Don't you think it would be a good idea for oil people to keep a list of persons who criticize it unnecessarily.

This could be a good project for the Association of Petroleum Writers. Is there any reason why we shouldn't try to turn our attackers into friends? When they make a mistaken statement they should be bombarded by letters explaining the situation from the oil industry's standpoint. Its operations are hard to understand. Many of us in the oil industry do not appreciate the complexity of the overall picture.

Andy Rowley, oil columnist for the Tulsa Tribune and secretary-treasurer of APW, has been keeping up with some St. Louis Post-Dispatch editorials on statements that were false and misleading. In this case if a large number of persons had written to the publisher and editor of the Post-Dispatch there might be developed some reluctance to print just anything about the oil industry.

When TIME, for instance, makes an unfriendly comment on the old subject, depletion, there should be enough letters in the office to keep the editors busy for awhile. This is direct fighting — fighting for what we believe and trying to convince the persons who are unfairly critical.

We should be big enough to take criticism when it fits, but a great deal of it is based on complete misunderstanding when it is not purely sensational. We should not allow public opinion to turn against us by default. We don't need to get hot-headed or unkind, but we can give a reasonable explanation that should be enlightening and any understanding will do us some good. Many of the associations work along this line, but it's going to take many voices in the oil industry to be heard in an impressive volume.

Bob Anderson President?

Betty Beale, Washington correspondent, released a story recently that the next Secretary of the Treasury, Bob Anderson, is President Eisenhower's choice for his successor. Anderson, a Vernon, Texas, man was for many years the executive vice president of the Texas Oil and Gas Association, and is well known in oil circles. He was also manager of the Waggoner Estates which has extensive oil interests. The report stated "The President once went on record before two men that he would like to see Texas-born-and-bred Bob Anderson become President of the United States." Formerly a Democrat, Anderson is now registered as a Republican.

A Bordering Science

The petroleum industry embraces all the sciences, among them archaeology. Pipeline companies have employed archaeologists in certain areas when they have dug ditches for the big lines.

Perhaps the important contribution archaeology makes to ours and every industry is the light it throws on the human race. Geoffrey Biddy in his "The Testimony of the Spade" (Published by Alfred A. Knopf, New York, 1956, pages 413, price $6.75) calls this "history in depth." In his account of life in northern Europe from 15,000 BC to the time of the Vikings, Biddy says "And every one of these succeeding generations was unique. Each of these great grandsons in turn saw the past as a process culminating in himself — saw the world as a new and exciting place and knew that history would end when he died."

Archaeology really began, Biddy says, only 150 years ago. His story of pre-history is made in the light of startling new discoveries. He tells of the slow spread of a succession of "barbarian" tribes north of the Alps, showing pre-history turning into history in the heart land of Europe. He says "Every archaeologist knows in his heart why he digs, in pity and humility, that the dead may live again, that what is past may not be forever lost, that something may be salvaged from the wrack of the ages, that the past may color the present and give heart to the future."

HIGHLIGHTS

★ ★ ★

Digest of News and Comment

$2,800,000 payment is being made by the Iraq Petroleum Company to 2800 discharged workers in Syria. The company is paying discharge indemnities plus full wages in accord with new Syrian law. The employees have been jobless since the oil flow across Syria was cut after the Anglo-French invasion of Egypt last November.

★ ★ ★

Bay Petroleum Corporation has acquired an outlet for an additional 200,000 bbl of products monthly through the recent purchase of 75 service stations and marketing facilities in three southeastern states. Bay, a subsidiary of Tennessee Gas Transmission Company, purchased most of the new facilities from Citizens Oil. The stations are in Georgia, Alabama and Florida. Bay operates refineries at New Orleans and Denver and has retail facilities in five states.

★ ★ ★

A critical point has been reached by the oil industry in Texas, reports the University of Texas Business Research Bureau. Although overall business activity was up three percent over May 1956, exceptions in crude petroleum production, crude runs to stills and electric power consumption were noted by the Bureau. Overall business activity index in Texas was up six percent in April over March and gained three percent more in May over April.

★ ★ ★

Success of a $65,000,000 gamble in Indonesia by Standard-Vacuum Oil Company back in 1946 has been featured in a report published by the National Planning Association. After World War II, Stanvac decided to pour more money into its war-demolished operations in Indonesia at a time when a revolutionary government was trying to free itself from a colonial empire. The company continues to exist — and grow — because of successful public and labor relations. Most important phase of Stanvac's program was its "I" or Indonesianization program, and contributions in housing, health, education, and construction of roads and airfields.

★ ★ ★

Gas utilities and pipelines have mapped a record budget calling for more than $2.1 billions for construction and expansion of present facilities this year. The report by the American Gas Association says the sum represents a 37 percent increase over last year's previous high of $1.5 billion. Almost half of the anticipated expenditure is to go for transmission purposes. One of the biggest single projects this year, the AGA points out, is the $154,000,000 Houston Oil and Gas and Coastal Transmission gas line project from Texas to Florida.

★ ★ ★

Department of Commerce has announced it will continue its program of utilizing WOC (without compensation) executives from industry in full-time positions with the Business and Defense Services Administration. Appointments of executives on loan from industry is being continued in positions of administrative adviser to the director, assistant division director, branch chief and consultant, while division directors in the future will be from the ranks of "qualified government career personnel." Secretary of Commerce Weeks stated that the "WOC's have earned well deserved praise," and said "This important public service will continue."

★ ★ ★

Twenty-six new tankers have been ordered by the British Petroleum Company in addition to its present program. The new tankers are estimated to cost $224,000,000 and will have a combined capacity of 1,150,000 deadweight tons. Delivery dates for the additions to BP's present fleet of 147 ocean-going tankers range between 1960 to 1963.

★ ★ ★

Downward adjustment in crude prices in Southwest Texas was noted early in July as one purchaser after another announced price reductions ranging from 5 to 18 cents per bbl. The cuts, laid to oversupply and a drop in refinery profits, wiped out from one-third to one-half of the increase put into effect early this year during the Suez crisis. Purchaser proration has been put into effect in some pools in the area.

★ ★ ★

Annual safety award winner, chosen by the exploration section of the National Safety Council, is The Carter Oil Company. During 1956 Carter's exploration operations personnel worked 1,418,800 man-hours with only one disabling injury. Company was competing in the contest with 13 other companies.

"Unfair labor practices" charges have been filed by Standard Oil Company of Ohio in conjunction with strikes at five refinery units of the company. Company spokesmen say the National Labor Relations Board set up bargaining units for each of the Sohio plants, and said that the union would not settle for any plant until all groups' agreements have been met, thus "circumventing the Labor Board's rulings." Company had already agreed to six percent wage increases.

★ ★ ★

Oil companies in Canada are helping carve a new industry in sulfur needed to supply the large pulp and paper mills of the dominion. Shell, British-American and Devon-Palmer oil companies are now among the major firms in producing, processing and marketing elemental sulfur from "the sourest gas in North America." Center of the new industry is in Alberta at Calgary, Pincher Creek and Jumping Pound.

★ ★ ★

Biggest member of the petro- chemical family, the synthetic rubber industry, is entering its greatest period of growth, says Raymond C. Firestone, president of Firestone Tire and Rubber Company. The company has announced a $35,000,000 synthetic rubber expansion program.

★ ★ ★

Sharp allowable cutbacks in Mid-Continent states have been defended by Ernest O. Thompson, member of the Texas Railroad Commission, as being the best course for the nation. Oil might still be 10 cents a bbl as it was in 1932 if market allowables had not been established and maintained. Thompson made the point at opening ceremonies of a new gasoline plant operated by Honolulu Oil Corporation near Brownfield, Texas. The area's wells were pared to a 13-day producing schedule during July.

★ ★ ★

Automotive gas turbines are almost ready to compete with piston engines, General Motor's engineers have told the Society of Automotive Engineers. The trio said gas turbines needed no additional engineering breakthroughs to put heavy turbine vehicles on the road, especially in the field of heavy-duty and military vehicles. Engines are light so loads can be heavier. More fuel is used, however, so the revenue is about the same.

J&L EXTREME LINE

CASING

for deep wells

- High strength joint
- 100% leak resistant

J&L Extreme Line casing meets the challenge of your toughest deep well problems. Check the unusual advantages of this new J&L casing available in grades J-55, N-80 and P-110. Produced under license from The National Supply Co. Write to Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30, Pa.

High joint strength. A modified Acme-type (rectangular thread form) thread with a steep flank angle assures a strong interlock, takes tensional loads in shear.

100% leak resistant. Separate sealing surfaces lock together when two lengths of casing are joined. Seal consists of a curved surface extending beyond the male threads and a tapered conical seat beyond the inside end of the mating female threads. The number of threaded connections is halved.

J&L STEEL **Jones & Laughlin** ... a great name in steel

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Trimmed July allowables, held steady in August by most states, is encouraging — but too late to be effective, says the monthly review of the oil situation issued by the Chase Manhattan Bank of New York. To effectively cut stocks to the desired levels, an additional reduction of 670,000 bbl per day in domestic production would be necessary. A desired stock level of 800,000,000 bbl had been set to be reached by November 1.

★ ★ ★

A $66,000,000 suit by the government claiming overcharges in oil purchases from private companies has been dismissed after nearly five years of litigation. The government had claimed that overcharges were made by companies from Middle East oil bought under the foreign aid program from September 1950 to August 1952. Involved were Standard of California, Texaco, Bahrein Petroleum, California Texas Oil, Caltex Oceanic, and Mid-East Crude Sales Company.

★ ★ ★

The U. S. export business is getting larger. A record $19 billion of merchandise is expected to be shipped from this country this year. This would be some $1.7 billion above 1956 imports, says the National Foreign Trade Council. The group indicates that 1957 commercial imports will be a record $13 billion.

★ ★ ★

National income and gross product figures for 1956 have been advanced from previous estimates, the Commerce Department's survey of current business shows. The gross national product, the nation's total of goods and services, totaled $414.7 billion. This is more than $2 billion higher than had previously been reported. The national income increased about 6 percent last year.

★ ★ ★

Steel price increases, effected in July, should be reflected in crude prices and services within the oil industry, trade association officials say. Robert L. Wood, president of the IPAA, said hikes will increase the industry's steel bill about $36,000,000 annually—and should increase the price of oil five cents per barrel. C. H. Todd, chairman of the accounting committee of the American Association of Oilwell Drilling Contractors, urged the organization's members to take into account the four percent steel increase in making bids for contract work.

Name changes are being made in the fast-moving American Petrofina organization. Officials have stated that American Liberty Oil Company, recently merged into Petrofina, will now operate under the name of American Petrofina Company of Texas, Division of American Petrofina, Inc. Properties formerly operated as the Panhandle Oil Division of American Petrofina, will be conducted under the new name.

Roger Motheral, The Petroleum Engineer's District Manager in Houston, died July 20.

Motheral, 53, was born in San Marcos, Texas, where he attended high school and business college. He was first engaged there in buying and selling. He entered the oil business first working as a roughneck in East Texas, West Texas, and in Mexico. At one time he was employed in Yuma, Arizona, by a tractor and automobile sales agency. Later he came to Fort Worth, Texas, to join the Chamber of Commerce, and was advertising manager of its publication "West Texas Today."

He joined the advertising staff of The Petroleum Engineer Publishing Company in 1936, and was stationed in Pittsburgh, Cleveland, and New York offices. In 1946 he was employed by the Gulf Publishing Company in Houston and left that organization as vice president in 1953. He returned to the staff of The Petroleum Engineer in 1954.

Motheral was very active in the Nomads and numerous advertising clubs both in the East and Southwest U. S.

He is survived by his wife Lois, a daughter, Carol Joan, and by his mother, Mrs. A. S. Motheral, of San Marcos. He is also survived by four sisters and three brothers. They are Bernice and Ellen Motheral, and Mrs. Max Smith, all of San Marcos; Mrs. Felix Gold and Hal Motheral, both of San Antonio, and Randle Motheral of Houston.

Motheral, his wife and daughter had made their home in Houston since 1953.

Oil companies have retained their top billing among the nation's 500 biggest industrial corporations, says Fortune magazine. Based on 1956 sales, 5 of the top 15 industrials were oil firms. General Motors is the biggest, followed by Jersey Standard in second place. Biggest change in rankings was noted by Socony Mobil, which jumped from thirteenth to sixth place last year with sales of $2.75 billion.

★ ★ ★

Five independent oil and gas producers' associations have filed a friend-of-the-court brief urging the Texas Supreme Court to uphold an order of the Texas Railroad Commission requiring ratable take of natural gas in a Pecos County gas field. A state court of civil appeals had upheld the order after a lower court had struck it down. The brief has asked the state's highest court to "dispel all doubt regarding the validity of Texas conservation statutes."

★ ★ ★

Hugh Roy Cullen, one of Texas' greatest philanthropists, died in Houston on July 4. Death of the 76-year-old oilman was attributed to cerebral thrombosis. It has been estimated that Cullen gave some $160,000,000 to charity during his lifetime. His gifts to the University of Houston, one of his favorite institutions, were said to exceed $30,000,000.

★ ★ ★

Texas Eastern Transmission Corporation stockholders have voted to acquire La Gloria Oil & Gas Company on a share-for-share basis for each of the Corpus Christi, Texas, firm's one million issues. La Gloria owns interest in 526 producing oil and gas wells in three states, a refinery in Tyler and a natural gas processing plant in Falfurrias, Texas. It supplies Texas Eastern with substantial amounts of natural gas. La Gloria would be operated as a subsidiary of the Shreveport, Louisiana, transmission company.

★ ★ ★

Over-supply situation in the oil industry will not be corrected until normal demand increases this fall, says a recent report of the Independent Petroleum Association of America. The association stated that if total demand for oil continues below forecast levels, as in the past three months, it would mean further reductions in domestic production, unless scheduled imports are curtailed. The alternative, IPAA points out, would be a "further burdensome accumulation of inventories."

Good Wells Make Good News

August, 1957

FRACTURING TREATMENTS often give better results when acid is used as part of the treatment. Here are four recent examples showing different ways Dowell has used acid to improve fracturing results.

- **Coleman County, North Texas** (Old Well): Production had declined to 3 bopd from well completed in Capps lime through perforations at 1907 to 1935 feet. Earlier treatments had been unsatisfactory. Dowell fractured with Riverfrac* using 20,000 gallons of water containing three per cent acid, F.L.A.* (Fluid Loss Additive), a de-emulsifying agent and 20,000 pounds sand. Injection down casing at 25 bpm. *Well stabilized at 20 bopd after treatment. As a result of success with this treatment, drilling was resumed in field.*

- **Caddo Parish, Louisiana** (New Well): Drilled into highly soluble Fredericksburg lime, 2374 to 2378 feet, in field where most wells are strippers. 1000-gallons Dowell acid spearhead was followed by Acid Petrofrac® using 10,000 gallons acid-in-oil emulsion and 20,000 pounds sand. Injected at 1800 psi and 25 bpm down casing. *After five days, well had produced 1000 barrels oil and was flowing through choke at 75 bopd.*

- **Matagorda County, South Texas** (New Well): Completed in Frio sandstone through perforations 8902 to 8924. Before fracturing, drill stem tested 680 psi on ¼-inch choke. Dowell provided Stratafrac®, using 12,000 gallons acid-kerosene emulsion with 30,000 pounds 60-80 mesh sand. Injection down 2-inch tubing at 6000 psi, 2½ to 5 bpm. Following treatment, well tested 1750 psi on ¼-inch choke and is now *producing 2000 mcf gas and 82 barrels distillate per day.*

- **Fort St. John, British Columbia, Canada** (New Gas Well): Drilled into Triassic "D" sand with perforations 4691 to 4709 feet. Well tested 18,000 mcfpd open flow. Dowell performed fracture treatment using 500 gallons Mud Acid followed by Petrofrac® using 20,000 gallons emulsified diesel oil with 20,000 pounds sand. Pumped down 2½-inch tubing through packer 4600 psi at 7 bpm. *Following quick clean-up, well tested 137,000 mcfpd open flow.*

These are just samples of the wide range of fracturing treatments provided by Dowell for good results in any formation. For more information or service, call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service. Or write Dowell Incorporated, Tulsa 1, Oklahoma.

Services for the oil industry DOWELL

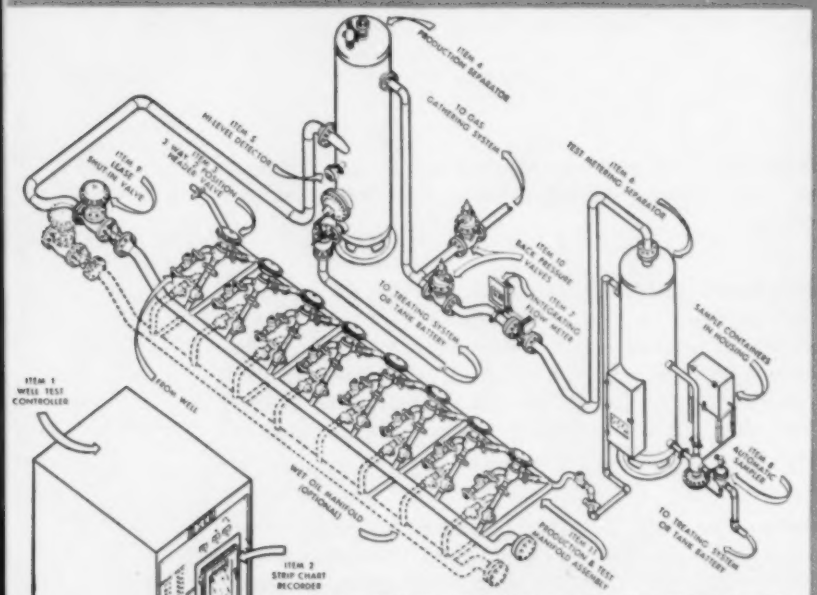
A Service Subsidiary of The Dow Chemical Company

*Trademark of Dowell Incorporated

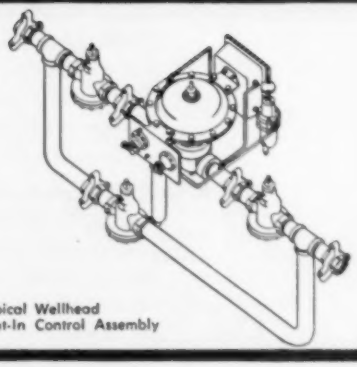
"BS&B Research Shows The Way!"

Only The New BS&B Phanto-Pumper Gives You Centralized Automatic . . .

- ✓ Wellhead Shut-In Control
- ✓ Well Test Control and Data Recording
- ✓ Well Flow Programming
- ✓ Tank Switching Control



Typical BS&B PHANTO-PUMPER Well Test Installation (Electro-Pneumatic) and Typical Well Test Control Panel With Strip Chart Recorder



Typical Wellhead Shut-In Control Assembly

. . . Or Any Combination Of These In One Packaged System!

The BS&B PHANTO-PUMPER is that part of BS&B's new PHANTO-MATIC Lease System which automatically performs all lease operations between the wellhead and the gaging to the pipeline. It is the oil industry's first commercially available standard equipment for providing any combination of *centralized automatic* . . .

1. **Wellhead Shut-In Control** . . . Various types of wellhead shut-in control assemblies provide correct control for any combination of well flowing or pumping conditions.
2. **Well Test Control And Data Recording** . . . Wells are automatically switched from production to test and data is recorded on strip chart. Upon completion of test, well is automatically placed back into production and next well is put on test. Wells may be tested in any sequence, or for any time period.
3. **Well Flow Programming** . . . Production from wells is automatically programmed to meet state requirements. When allowable production has been reached, wells are automatically shut in.
4. **Tank Switching Control** . . . Tank battery control equipment automatically fills all tanks to capacity in a preset sequence, and automatically by-passes tanks already full or being run to pipeline, or to metering equipment.

The entire PHANTO-PUMPER System is designed "fail safe" so that in case of power failure or shut down, it will halt operations immediately until the trouble is remedied, and then will automatically start again at the same part of the sequence where it had ceased.

With the PHANTO-PUMPER System, the element of human error in lease operation is virtually eliminated by "set-and-forget" automatic controls which operate the system more accurately and economically than has ever heretofore been practical or possible.

The BS&B PHANTO-PUMPER and the BS&B PHANTO-GAGER together make up the complete BS&B PHANTO-MATIC Lease System which provides full lease automation from the wellhead to the pipeline. PHANTO-GAGER Systems automatically perform the following functions:

1. Measurement and recording of temperature compensated oil volume in barrels.
2. Measurement (or automatic sampling and subsequent determination) of quality and contaminant.
3. Running of crude from lease into connecting pipeline in accordance with predetermined schedules on an unattended basis.

OFFICIENCY OVER 60 YEARS BS&B RELIABILITY — ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

Ask Your BS&B Man For Full Details, or write to . . .

BLACK, SIVALLS & BRYSON, INC.

Oilfield Equipment Division, Dept. 1-C8
P. O. Box 1714 Oklahoma City, Oklahoma

Meetings

Aug. 15—**API, OIC,** Steering Committee meeting, Biltmore Hotel, New York City.

Aug. 18-23—**National Congress of Petroleum Retailers,** 11th annual session, Sheraton Gibson Hotel, Cincinnati, Ohio.

Aug. 20-22—**Conference on Liquid Scintillation Counting.** Technological Institute, Northwestern University, Evanston, Ill.

Aug. 26-28—**Appalachian Gas Measurement Short Course,** 17th annual, West Virginia University, Morgantown, West Virginia.

Aug. 28-30—**International Symposium on Gas Chromatography,** Analysis Instrumentation Committee of the Instrument Society of America, Kellogg Center for Continuing Education, East Lansing, Michigan.

Aug. 30-31—**Association of Desk & Derrick Clubs of North America,** annual meeting, Hilton Hotel, Chicago, Illinois.

Sept. 3-5—**Pacific Coast Gas Association Convention,** San Francisco, California.

Sept. 5-6—**API Oil Information Committee meeting,** Broadmoor Hotel, Colorado Springs, Colorado.

Sept. 8-13—**American Chemical Society,** 132nd national meeting, New York City.

Sept. 9-11—**American Institute of Electrical Engineers,** petroleum industry conference, Sheraton Hotel, Philadelphia, Pennsylvania.

Sept. 9-13—**12th Annual Instrument Automation Conference and Exhibit,** sponsored by Instrument Society of America, Cleveland Auditorium, Cleveland, Ohio.

Sept. 10-11—**Petroleum Packaging Committee,** quarterly meeting, Hotel Guildwood Inn, Point Edward, Ontario, Canada.

Sept. 11-13—**National Petroleum Association,** 55th annual meeting, Hotel Traymore, Atlantic City, New Jersey.

Sept. 12-14—**Wyoming Geological Association,** 12th annual field conference, Southwestern Wind River Basin, Lander, Wyoming.

Sept. 15-18—**AIChE,** Lord Baltimore Hotel, Baltimore, Maryland.

Sept. 22-24—**Independent Oil Compounders Association,** 10th annual meeting, Carter Hotel, Cleveland, Ohio.

Sept. 22-25—**American Society of Mechanical Engineers,** Petroleum Division, 12th annual Petroleum Mechanical Conference, Mayo Hotel, Tulsa, Oklahoma.

Sept. 23-24—**Steel Founders' Society of America,** 55th fall meeting, The Homestead, Hot Springs, Virginia.

Sept. 23-25—**American Society of Mechanical Engineers,** fall meeting, Statler Hotel, Hartford, Connecticut.

Sept. 26-27—**Western Petroleum Refiners Association,** regional technical-industrial relations meeting, Henning Hotel, Casper, Wyoming.

Sept. 26-27—**Louisiana-Arkansas Division Mid-Continent Oil & Gas Association,** annual membership meeting, Roosevelt Hotel, New Orleans, Louisiana.

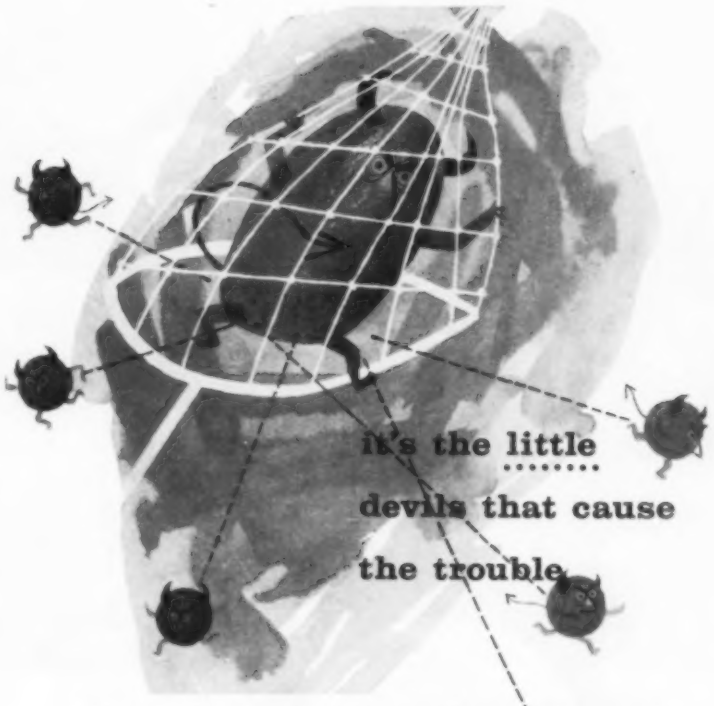
Sept. 27—**Natural Gasoline Association of America,** Oklahoma regional, Skirvin Hotel, Oklahoma City, Oklahoma.

Sept. 30-Oct. 2—**American Oil Chemists' Society,** 1957 fall meeting, Netherland Plaza Hotel, Cincinnati, Ohio.

Oct. 1-2—**Texas Mid-Continent Oil & Gas Association,** 38th annual meeting, Texas Hotel, Fort Worth, Texas.

Oct. 1-2—**API Executive Committee of Board of Directors,** Greenbrier Hotel, White Sulphur Springs, West Virginia.

Oct. 6-9—**The Society of Petroleum Engineers, AIME,** 32nd annual fall meeting, Adolphus, Baker and Statler Hilton hotels, Dallas, Texas.



In water flooding, almost any treatment will remove the larger solids. However, the microscopic hellions — algae and bacteria, particularly the sulphate-reducing bacteria — are what really play hob with the flood zone. And conventional treatment lets most of them through. But Dicalite filtration nets them securely, because Dicalite filteraids can filter out particles smaller than the wave length of visible light, particles so small you can't see 'em with a microscope!

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UREABOR®
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Oct. 6-10—**ASTM Committee D-2 meeting,** Sheraton-Park Hotel, Washington.

Oct. 7-9—**ASME, ASLE-ASME Lubrication Conference,** Royal York Hotel, Toronto, Ontario, Canada.

Oct. 7-9—**American Gas Association,** annual convention, Kiel Auditorium, St. Louis, Missouri.

Oct. 7-9—**National Electronics Conference,** 13th annual, co-sponsored by Illinois Institute of Technology and two other universities and two technical societies, Hotel Sherman, Chicago, Illinois.

Oct. 7-11—**American Institute of Electrical Engineers,** 1957 fall general meeting, Morrison Hotel, Chicago, Illinois.

Oct. 10-12—**ASME, Fuels-AIME conference,** Chateau Frontenac, Quebec City, Quebec, Canada.

Oct. 13-15—**American Association of Oilwell Drilling Contractors,** 17th annual meeting, Mayo Hotel, Tulsa, Oklahoma.

Oct. 13-16—**American Petroleum Credit Association,** 33rd annual conference, Mark Hopkins Hotel, San Francisco, California.

Oct. 16-17—**South Dakota Independent Oil Men's Association convention,** Alonzo Ward Hotel, Aberdeen, South Dakota.

Oct. 17-18—**The Society of Petroleum Engineers, AIME,** Southern California Petroleum Section, fall meeting, Biltmore Hotel, Los Angeles, California.

Oct. 20-22—**National Association of Oil Equipment Jobbers,** annual convention and trade show, Hotel Peabody, Memphis, Tennessee.

Oct. 21-23—**American Society of Mechanical Engineers,** conference on development in the field of power, Allentown, Pennsylvania.

Oct. 23-24—**Computer Applications Symposium,** sponsored by Armour Research Foundation, Hotel Sherman, Chicago, Illinois.

Oct. 24-25—**Western Petroleum Refiners Association,** regional technical-industrial relations meeting, Rufus Garrett Hotel, El Dorado, Arkansas.

Oct. 25—**Natural Gasoline Association of America,** southern regional, Washington-Youree and Captain Shreve hotels, Shreveport, Louisiana.

Oct. 27-29—**Independent Petroleum Association of America,** annual meeting, Statler-Hilton Hotel, Dallas, Texas.

Oct. 31-Nov. 1—**AAPG Mid-Continent** regional meeting, Cimarron Ballroom, Tulsa Oklahoma.

Nov. 6-8—**Gulf Coast Association of Geological Societies,** 7th annual convention, Roosevelt Hotel, New Orleans, Louisiana.

Nov. 11-13—**Steel Founders' Society of America,** 12th Technical and Operating Conference, Carter Hotel, Cleveland, Ohio.

Nov. 11-14—**API,** 37th annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 12-14—**National Association of Corrosion Engineers,** Northeast region, fall meeting, Penn-Sheraton Hotel, Pittsburgh, Pennsylvania.

Nov. 13-14—**Air Pollution Conference,** co-sponsored by Armour Research Foundation and Midwestern Air Pollution Prevention Association, Loop Hotel, Chicago, Illinois.

Nov. 22—**Natural Gasoline Association of America,** Panhandle Plains regional, Herring Hotel, Amarillo, Texas.

Dec. 1-6—**American Society of Mechanical Engineers,** annual meeting, Statler Hotel, New York City.

Dec. 5-6—**API Oil Information Committee Meeting,** Biltmore Hotel, New York City.

Dec. 8-11—**American Institute of Chemical Engineers,** annual meeting, Conrad Hilton Hotel, Chicago, Illinois.

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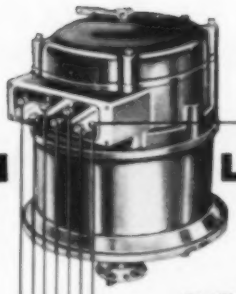

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Now you can have this greater capacity for long-term, trouble-free ignition, with higher KV output, plus low tension safety. Specify the MGC Pulse Generator System for *your* engines. American Bosch, Springfield 7, Mass. A Division of American Bosch Arma Corporation.

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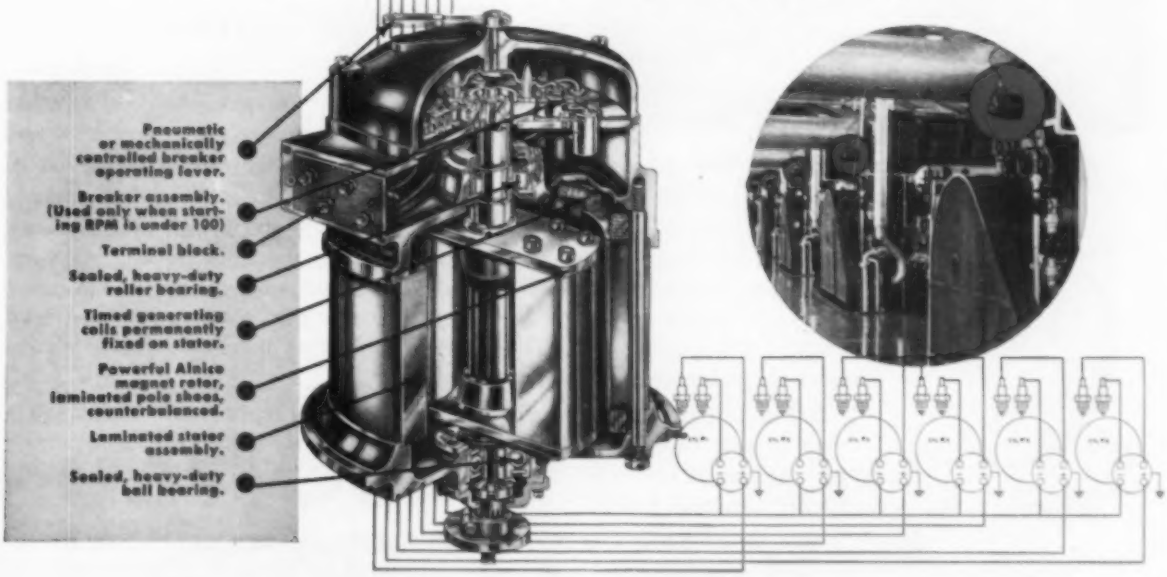
Pneumatic or mechanically controlled breaker operating lever.
Breaker assembly. (Used only when starting RPM is under 100)
Terminal block.
Sealed, heavy-duty roller bearing.
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Powerful Alnico magnet rotor, laminated pole shoes, counterbalanced.
Laminated stator assembly.
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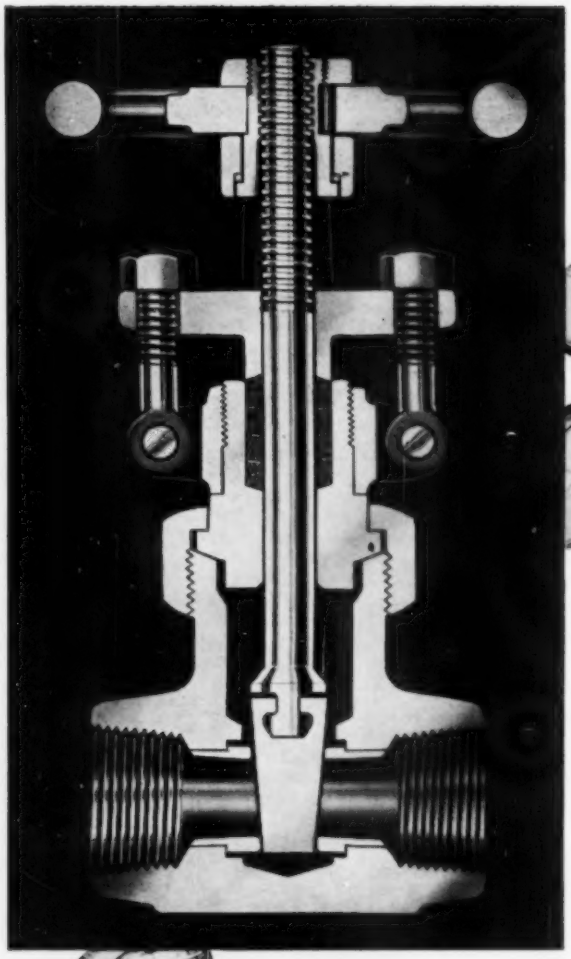

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186,000 BBLS. IN NEW STORAGE CAPACITY, AND—

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It happened at Knoxville, Tenn. That's where General American built a 6-tank terminal—including a 55,000 bbl. jet fuel pipeline storage tank—for Republic Oil Refining Company, a Division of Plymouth Oil Company.

"General American's unique experience in constructing and operating their own terminals helped us with our problems," says Holland Howell, Republic's chief engineer. "What's more, we found General American's 12-18 month payout estimate quite conservative. Through savings in filling and breathing losses alone, *the installation of floating roofs paid off in only 6 months!*"

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It's quite simple

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Whenever all these 9 specifications are applied to all the operating requirements, you can be sure PETROCHEM ISOFLOW FURNACES will be found most economically desirable.
No other furnace design can claim the recognition and acceptance achieved by PETROCHEM ISOFLOW FURNACES . . . starting with one installation in 1940, January '57 records more than 1650 ISOFLOW FURNACES in operation and under construction—a record that is incomparable just as all Petrochem Isoflow furnaces are more economically desirable by any comparison.

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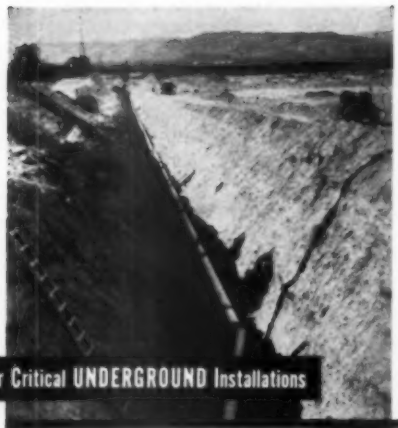

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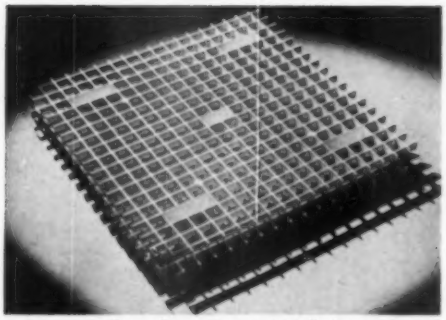
Measured depth, ft.	Deviation, degrees from vertical																							
	1		2		3		4		5		6		7		8		9		10		11		12	
	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V	H	V
500	9	.1	17	.3	26	.7	35	1.2	44	1.9	52	2.7	61	3.7	70	4.9	78	6.2	87	7.6	95	9	104	11
750	13	.1	26	.5	39	1.0	52	1.8	65	2.9	78	4.1	91	5.6	104	7.3	117	9.2	130	11	143	14	156	16
1,000	17	.2	35	.6	52	1.4	70	2.4	87	3.8	105	5.5	122	7.4	139	9.7	156	12	174	15	191	18	208	22
1,200	21	.2	42	7	63	1.6	84	2.9	105	4.6	125	6.6	146	8.9	167	12	188	15	208	18	229	22	249	26
1,400	24	.2	49	.8	73	1.9	98	3.4	122	5.3	146	7.7	171	10	195	14	219	17	243	21	267	26	291	31
1,600	28	.2	56	1.0	84	2.2	112	3.9	139	6.1	167	8.8	195	12	223	16	250	20	278	24	305	29	333	35
1,800	31	.3	63	1.1	94	2.5	126	4.4	157	6.9	188	9.9	219	13	251	18	282	22	313	27	343	33	374	39
2,000	35	3	70	1.2	105	2.7	140	4.9	174	7.6	209	11	244	15	278	19	313	25	347	30	382	37	416	44
2,200	38	.3	77	1.3	115	3.0	153	5.4	192	8.4	230	12	268	16	306	21	344	27	382	33	420	40	457	48
2,400	42	.4	84	1.5	126	3.3	167	5.9	209	9.1	251	13	292	18	334	23	375	30	417	36	458	44	499	52
2,600	45	4	91	1.6	136	3.6	181	6.3	227	9.9	272	14	317	19	362	25	407	32	451	39	496	48	541	57
2,800	49	.4	98	1.7	147	3.8	195	6.8	244	11	293	15	341	21	390	27	438	34	486	43	534	51	582	61
3,000	52	4	105	1.8	157	4.1	209	7.3	261	11	314	16	366	22	418	29	469	37	521	46	572	55	624	66
3,200	56	5	112	2.0	167	4.4	223	7.8	279	12	334	18	390	24	445	31	501	39	556	49	611	59	665	70
3,400	59	5	119	2.1	178	4.7	237	8.3	296	13	355	19	414	25	473	33	532	42	590	52	649	62	707	74
3,600	63	5	126	2.2	188	4.9	251	8.8	314	14	376	20	439	27	501	35	563	44	625	55	687	66	748	79
3,800	66	6	133	2.3	199	5.2	265	9.3	331	14	397	21	463	28	529	37	594	47	660	58	725	70	790	83
4,000	70	6	140	2.4	209	5.5	279	9.8	349	15	418	22	487	30	557	39	626	49	695	61	763	73	832	87
4,200	73	6	147	2.6	220	5.8	293	10	366	16	439	23	512	31	585	41	657	52	729	64	801	77	873	92
4,400	77	7	154	2.7	230	6.0	307	11	384	17	460	24	536	33	612	43	688	54	764	67	840	81	915	96
4,600	80	7	161	2.8	241	6.3	321	11	401	18	481	25	561	34	640	45	720	57	799	70	878	85	956	101
4,800	84	7	168	2.9	251	6.6	335	12	418	18	502	26	585	36	668	47	751	59	834	73	916	88	998	105
5,000	87	8	175	3.0	262	6.9	349	12	436	19	523	27	609	37	696	49	782	62	868	76	954	92	1,040	109
5,200	91	8	181	3.2	272	7.1	363	13	453	20	544	28	634	39	724	51	813	64	903	79	992	96	1,081	114
5,400	94	8	188	3.3	283	7.4	377	13	471	21	564	30	658	40	752	53	845	66	938	82	1,030	99	1,123	118
5,600	98	8	195	3.4	293	7.7	391	14	488	21	585	31	682	42	779	54	876	69	972	85	1,069	103	1,164	122
5,800	101	9	202	3.5	304	8.0	405	14	506	22	606	32	707	43	807	56	907	71	1,007	88	1,107	107	1,206	127
6,000	105	9	209	3.7	314	8.2	419	15	523	23	627	33	731	45	835	58	939	74	1,042	91	1,145	110	1,247	131
6,500	113	1.0	227	4.0	340	8.9	453	16	567	25	679	36	792	48	905	63	1,017	80	1,129	99	1,240	119	1,351	142
7,000	122	1.1	244	4.3	366	9.6	488	17	610	27	732	38	853	52	974	68	1,095	86	1,216	106	1,336	129	1,455	153
7,500	131	1.1	262	4.6	393	10	523	18	654	29	784	41	914	56	1,044	73	1,173	92	1,302	114	1,431	138	1,559	164
8,000	140	1.2	279	4.9	419	11	558	20	697	30	836	44	975	60	1,113	78	1,251	98	1,389	122	1,526	147	1,663	175
8,500	148	1.3	297	5.2	445	12	593	21	741	32	889	47	1,036	63	1,183	83	1,330	105	1,476	129	1,622	156	1,767	186
9,000	157	1.4	314	5.5	471	12	628	22	784	34	941	49	1,097	67	1,253	88	1,408	111	1,563	137	1,717	165	1,871	197
9,500	166	1.4	332	5.8	497	13	663	23	828	36	993	52	1,158	71	1,322	92	1,486	117	1,650	144	1,813	175	1,975	208
10,000	175	1.5	349	6.1	523	14	698	24	872	38	1,045	55	1,219	74	1,392	97	1,564	123	1,736	152	1,908	184	2,079	218
10,500	183	1.6	366	6.4	550	14	732	26	915	40	1,098	58	1,280	78	1,461	102	1,643	129	1,823	160	2,004	193	2,183	229
11,000	192	1.6	384	6.7	576	15	767	27	959	42	1,150	60	1,341	82	1,531	107	1,721	135	1,910	167	2,099	202	2,287	240
11,500	201	1.7	401	7.0	602	16	802	28	1,002	44	1,202	63	1,402	86	1,600	112	1,799	142	1,997	175	2,194	211	2,391	251
12,000	209	1.8	419	7.3	628	16	837	29	1,046	46	1,254	66	1,462	89	1,670	117	1,877	148	2,084	182	2,290	220	2,495	262
12,500	218	1.9	436	7.6	654	17	872	30	1,090	48	1,307	68	1,523	93	1,740	122	1,955	154	2,171	190	2,385	230	2,599	273

[1]Assuming uniform deviation all in one direction. The figures for horizontal displacement are therefore a maximum limit.

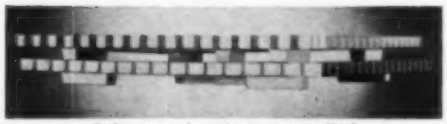
Horizontal and vertical displacement for intermediate depths or horizontal displacement for intermediate angles may be determined by interpolation. Vertical displacement for angles not included in the table may be determined by multiplying the measured depth by 1 minus the cosine of the angle. $V = D\,(1 - \cos\theta)$. The vertical depth of crooked holes is always less than the measured depth.

announcing

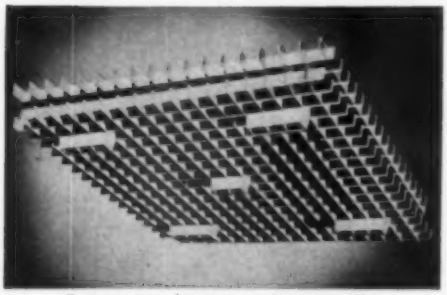
FLUOR'S NEW *poly-* GRID



Overall top view as installed



Side view of packing as installed



Bottom view showing spacing supports

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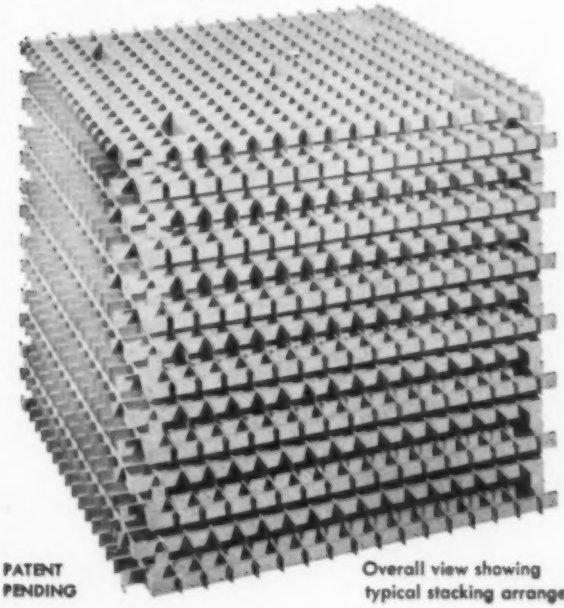
To increase the throughput of your existing counterflow induced draft cooling tower, Fluor Products Company now offers "Poly-Grid" packing.

This revolutionary packing provides greater cooling surface — greater overall heat transfer; yet construction is open, and pressure drop low.

"Poly-Grid" is available in high impact polystyrene or linear-polyethylene to meet all water conditions.

Fluor "Poly-Grid" packing allows you to cool more water under existing operating conditions, or to realize extra cooling of present throughput — all at minimum capital expenditure.



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Overall view showing typical stacking arrangement

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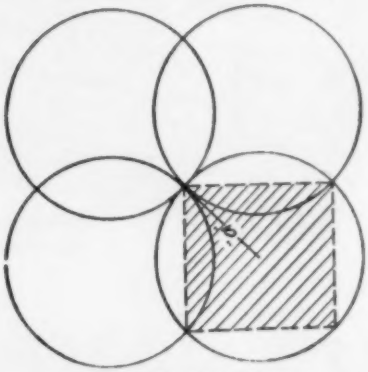
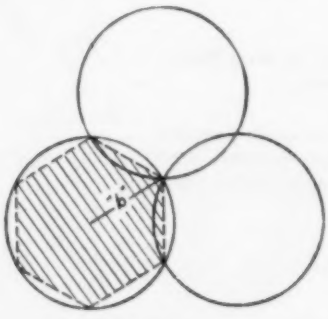
DRAINAGE BY UNIFORMLY SPACED WELLS

Spacing ft.	Area drained acres per well		Maximum drainage distance, ft. (see diagrams)	
	Regular	Staggered[1]	Regular "a"	Staggered "b"
60	.083	.072	42.4	34.6
70	.112	.097	49.5	40.4
80	.147	.127	56.6	46.2
90	.186	.161	63.6	52.0
100	.230	.199	70.7	57.7
110	.278	.241	77.8	63.5
120	.331	.286	84.8	69.3
130	.388	.336	91.9	75.1
140	.450	.390	99.0	80.8
150	.517	.447	106	86.6
160	.588	.509	113	92.4
170	.663	.575	120	98.2
180	.744	.644	127	104
190	.829	.718	134	110
200	.918	.795	141	115
210	1.01	.877	148	121
220	1.11	.962	156	127
230	1.21	1.05	163	133
240	1.32	1.15	170	139
250	1.43	1.24	177	144
260	1.55	1.34	184	150
270	1.67	1.45	191	156
280	1.80	1.56	198	162
290	1.93	1.67	205	167
300	2.07	1.79	212	173
310	2.21	1.91	219	179
320	2.35	2.04	226	185
330	2.50	2.17	233	191
340	2.65	2.30	240	196
350	2.81	2.44	247	202
360	2.98	2.58	255	208
370	3.14	2.72	262	214
380	3.31	2.87	269	219
390	3.49	3.02	276	225
400	3.67	3.18	283	231
410	3.86	3.34	290	237
420	4.05	3.51	297	242
430	4.24	3.68	304	248
440	4.44	3.85	311	254
450	4.65	4.03	318	260
460	4.86	4.21	325	266
470	5.07	4.39	332	271
480	5.29	4.58	339	277
490	5.51	4.77	346	283
500	5.74	4.97	354	289
510	5.97	5.17	361	294
520	6.21	5.38	368	300
530	6.45	5.58	375	306
540	6.69	5.80	382	312
550	6.94	6.01	389	318
560	7.20	6.23	396	323
570	7.46	6.46	403	329
580	7.72	6.69	410	335
590	7.99	6.92	417	341
600	8.26	7.16	424	346
610	8.54	7.40	431	352
620	8.82	7.64	438	358
630	9.11	7.89	445	364
640	9.40	8.14	452	370
650	9.70	8.40	460	375
660	10.0	8.66	467	381
670	10.3	8.92	474	387
680	10.6	9.19	481	393
690	10.9	9.47	488	398
700	11.2	9.74	495	404
710	11.6	10.0	502	410
720	11.9	10.3	509	416
730	12.2	10.6	516	421
740	12.6	10.9	523	427
750	12.9	11.2	530	433
760	13.3	11.5	537	439
770	13.6	11.8	544	445
780	14.0	12.1	551	450
790	14.3	12.4	559	456
800	14.7	12.7	566	462
820	15.4	13.4	580	473
840	16.2	14.0	594	485
860	17.0	14.7	608	497
880	17.8	15.4	622	508
900	18.6	16.1	636	520
920	19.4	16.8	650	531
940	20.3	17.6	665	543
960	21.2	18.3	679	554
980	22.0	19.1	693	566
1000	23.0	19.9	707	577
1020	23.9	20.7	721	589
1040	24.8	21.5	735	600
1060	25.8	22.3	749	612
1080	26.8	23.2	764	624
1100	27.8	24.1	778	635
1120	28.8	24.9	792	647
1140	29.8	25.8	806	658
1160	30.9	26.8	820	670
1180	32.0	27.7	834	681
1200	33.1	28.6	848	693
1220	34.2	29.6	863	704
1240	35.3	30.6	877	716
1260	36.4	31.6	891	727
1280	37.6	32.6	905	739
1300	38.8	33.6	919	751
1320	40.0	34.6	933	762

[1]Distances between wells in any direction equal, forming equilateral triangles.



REGULAR SPACING

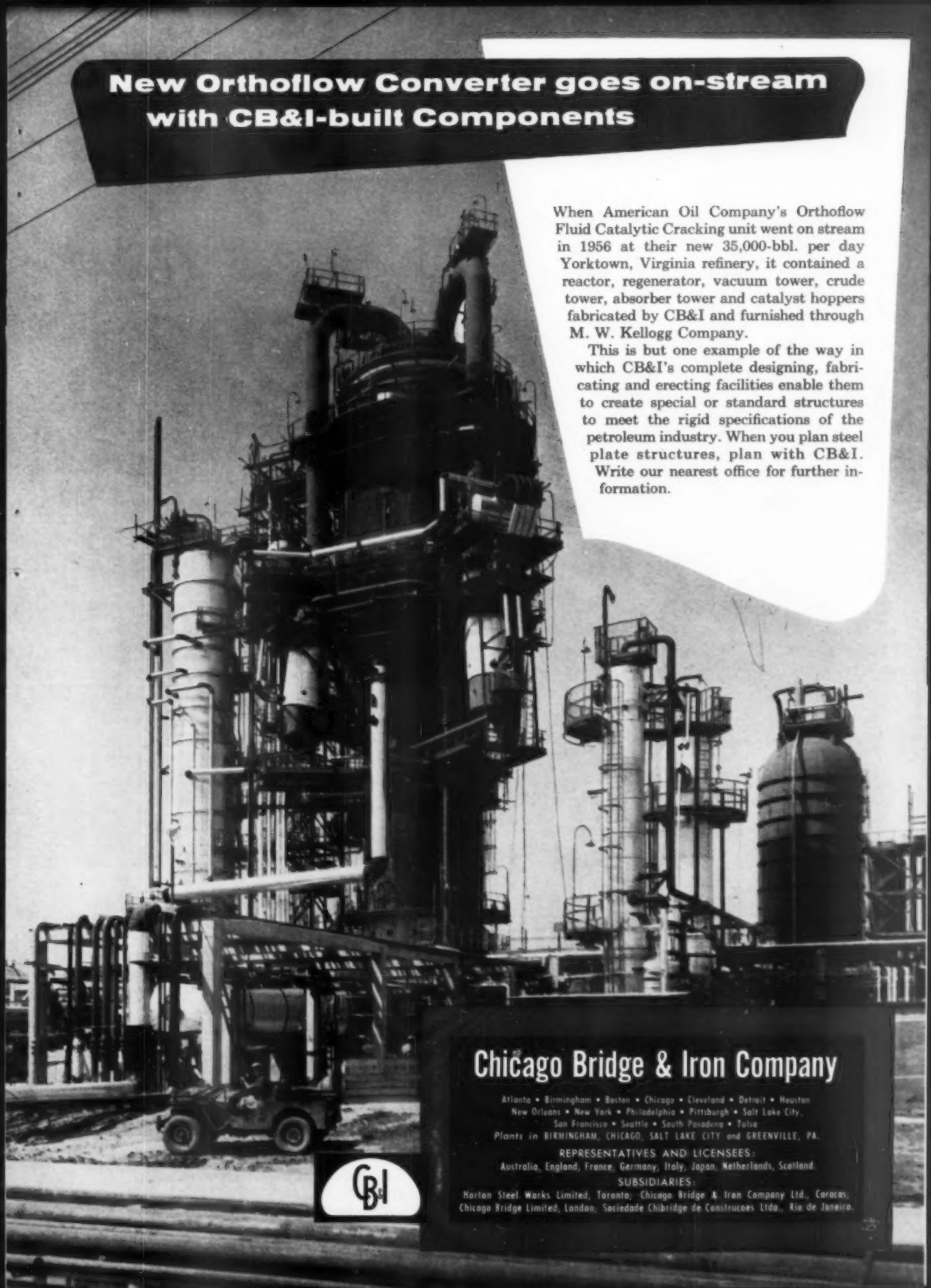


STAGGERED SPACING

Source: *The Petroleum Engineer's* CONTINUOUS TABLES

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

New Orthoflow Converter goes on-stream with CB&I-built Components



When American Oil Company's Orthoflow Fluid Catalytic Cracking unit went on stream in 1956 at their new 35,000-bbl. per day Yorktown, Virginia refinery, it contained a reactor, regenerator, vacuum tower, crude tower, absorber tower and catalyst hoppers fabricated by CB&I and furnished through M. W. Kellogg Company.

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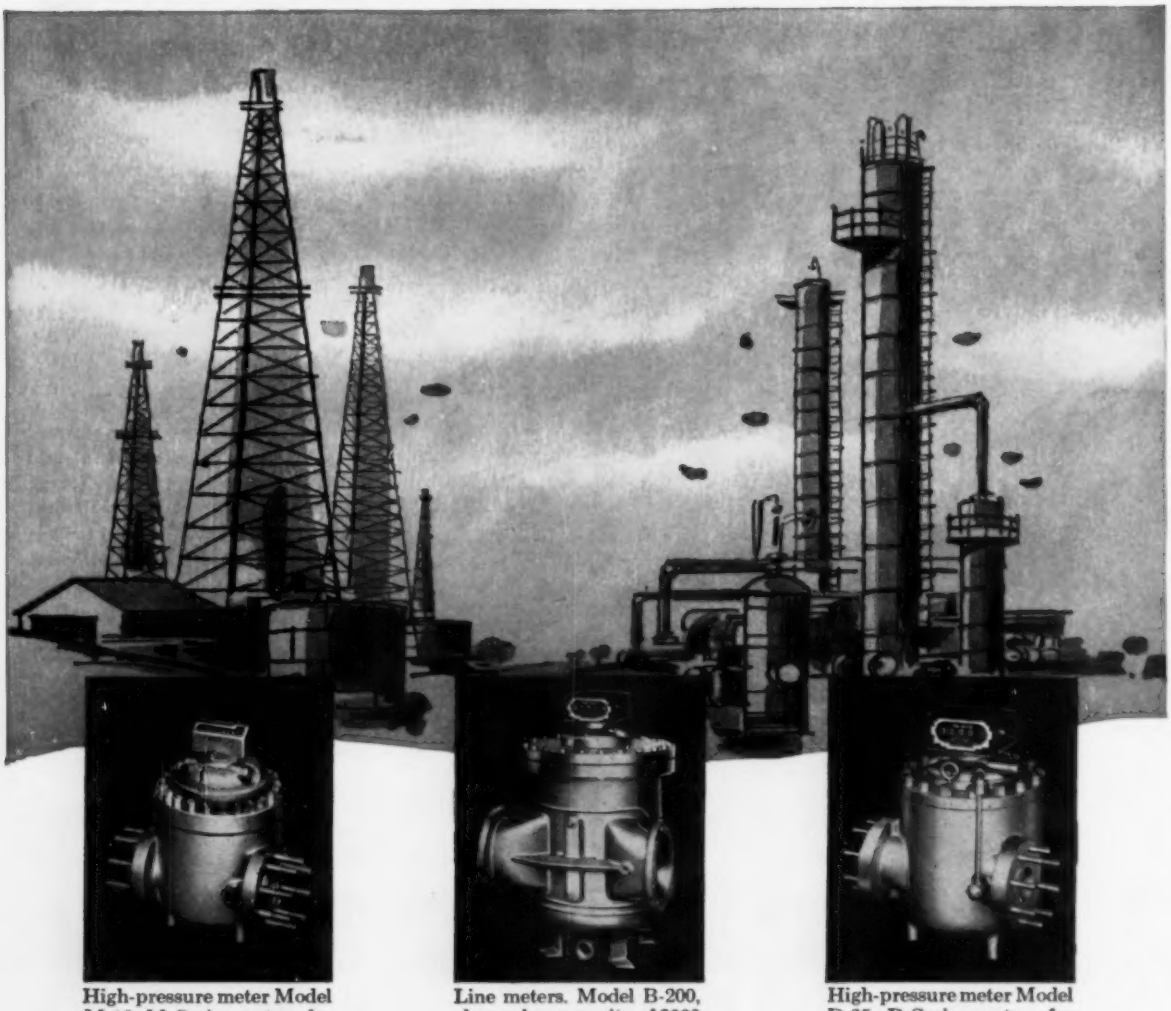

High-pressure meter Model M-12. M Series meters for working pressures up to 1200 psi, 120 gpm.

Line meters. Model B-200, shown, has capacity of 3000 bbl/hr. New Model B-700 — 10,000 bbl/hr.

High-pressure meter Model D-35. D-Series meters for working pressures up to 600 psi, capacity 350 gpm.

For wellsite or refinery, rely on A. O. Smith Meters . . .

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The day you install A. O. Smith high-pressure meters is the day you start to gain. A. O. Smith meters help safeguard against loss in production, processing and delivery because they're as close to being foolproof as modern science can make them.

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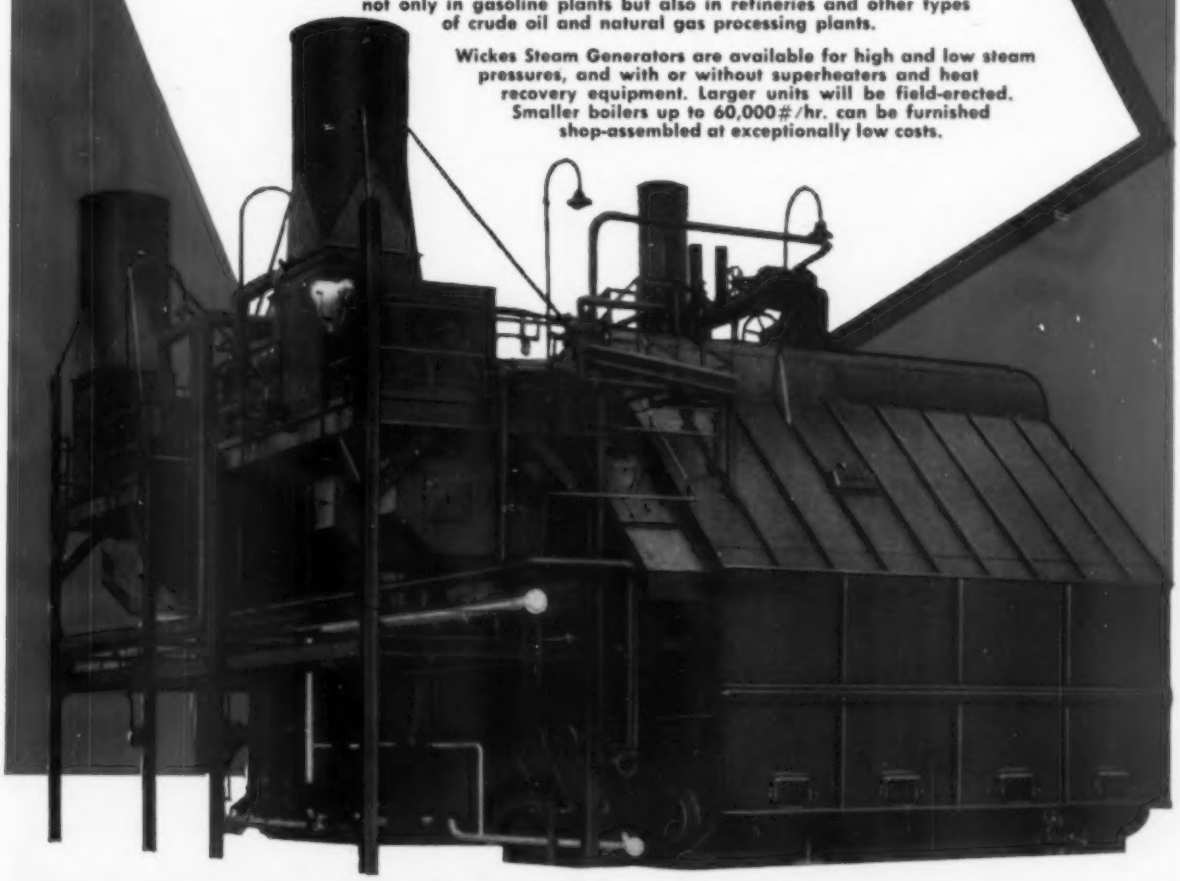
Wickes steam generators

The two Wickes A-Type Steam Generators shown here are installed in a large natural gas treating plant in the Southwest. They are field-erected and designed for outdoor operation under any weather condition. These units have been in continuous operation since 1949 and have demonstrated that Wickes Boilers can be relied upon as a dependable, economical source of steam, so vitally important in this type of plant

Wickes Steam Generators are finding ever increasing acceptance, not only in gasoline plants but also in refineries and other types of crude oil and natural gas processing plants.

Wickes Steam Generators are available for high and low steam pressures, and with or without superheaters and heat recovery equipment. Larger units will be field-erected. Smaller boilers up to 60,000#/hr. can be furnished shop-assembled at exceptionally low costs.



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Walworth Cast Steel Lubricated Plug Valves enjoy a long record of successful service on pipelines the world over. In design, construction and performance they stand unsurpassed.

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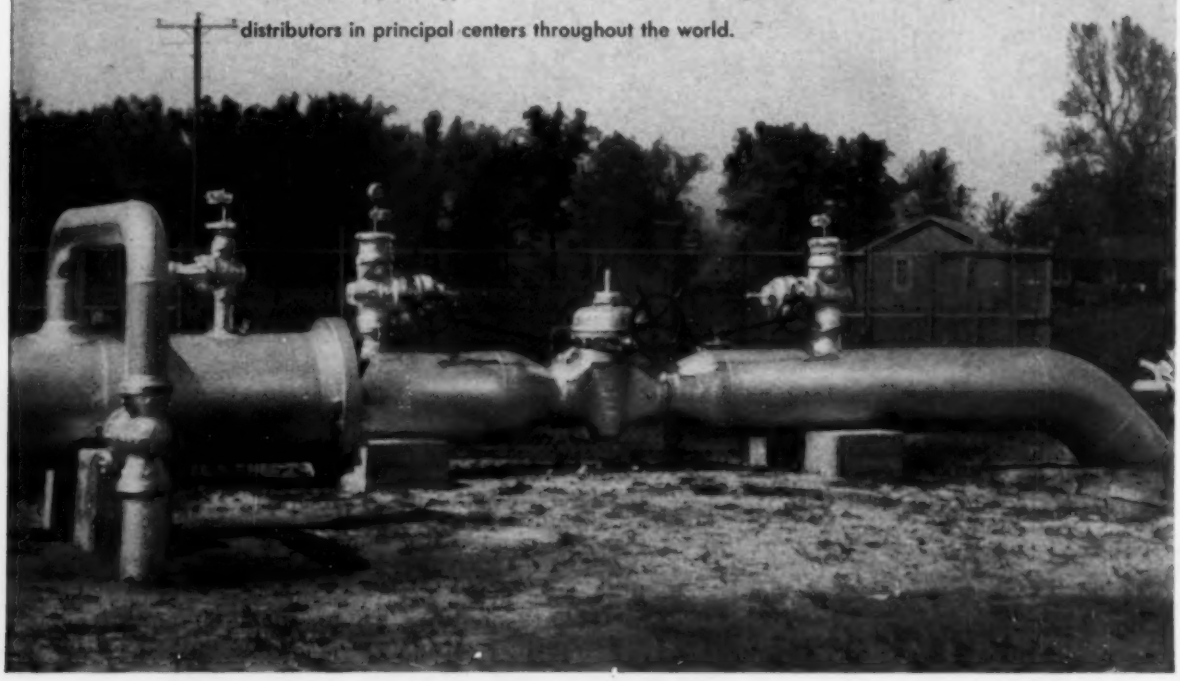

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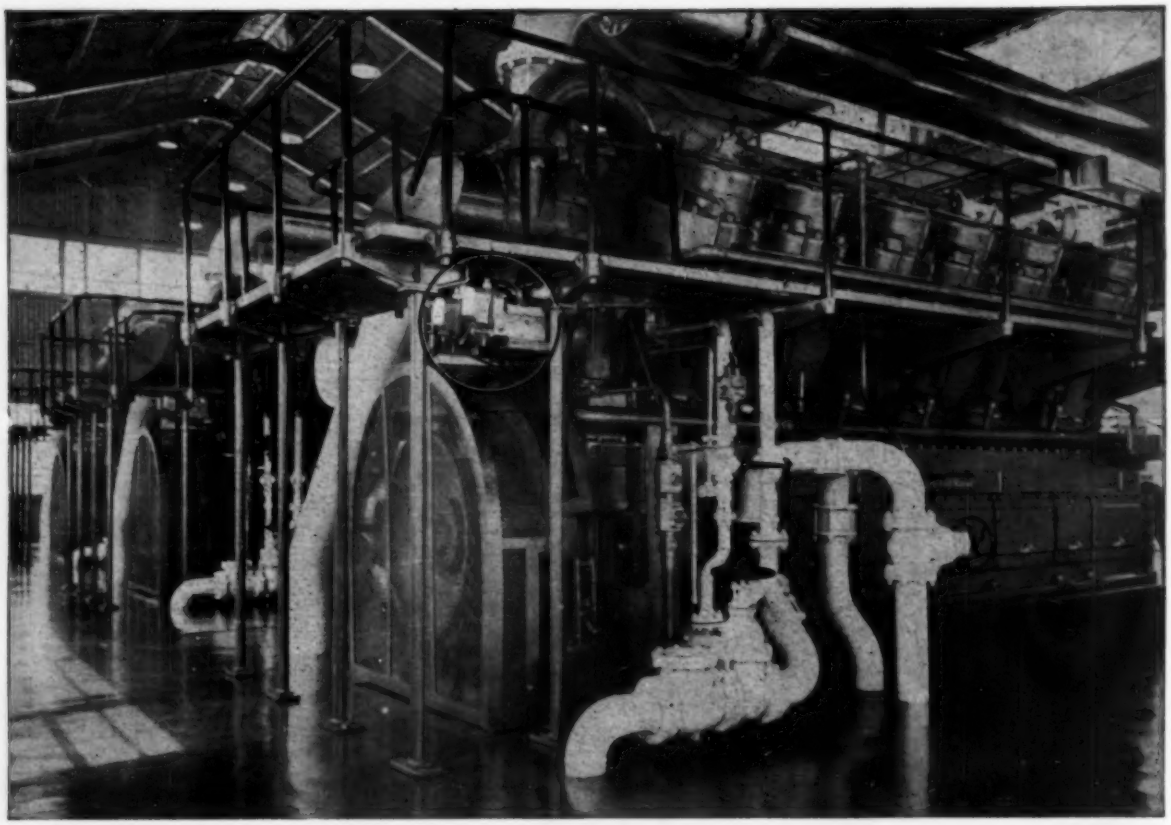

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Matched Ignition System

Trunkline Gas Company of Houston, Texas, operates a natural gas transmission line extending from near McAllen, Texas, to Tuscola in central Illinois where it connects with the line of the Panhandle Eastern Company.

This gas line crosses Texas, Louisiana, Arkansas, Mississippi, Tennessee, Kentucky, and the southern half of Illinois —a vital link in the nation's economy.

Helping to serve this very important segment of the nation's natural gas transmission system is the battery of Ingersoll-Rand 412 KVS engines equipped with Bendix DLC6 magnetos and Bendix HI-V transformer coils (illustrated at left) in Trunkline's Cypress Compressor Station near Houston.

The Bendix DLC6 magneto is a completely new type of magneto, incorporating the latest engineering design. Together with the Bendix HI-V transformer coil it becomes a matched ignition system that delivers more than ample voltage with greatly reduced maintenance cost.

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Why should Management be interested in OPERATIONS RESEARCH?

Vital part of management's job is decision-making... Only adequate information can produce prompt and accurate decisions... Here comes a new tool to aid in a scientific approach

Gilbert C. Jacobus

PROGRESSIVE management today recognizes that it needs to take full advantage of every instrument and technique that will aid in the accomplishment of its tasks. That management's responsibilities have enlarged tremendously in scope and complexity is no news to any thoughtful person in management nor to anyone who reads current literature in the field.

This article is intended to examine one of the valuable techniques available to managers, a technique shrouded somewhat in an atmosphere of mysticism for the layman because it has developed a language of its own, and because usually it draws heavily on the language and methodology of mathematics. We all know that knowledge of higher mathematics is usually not one of the manager's strong points.

Managerial Decision-Making

Basically management's job is to push back limitations, to convert difficulties into opportunities. The manager has to take responsibility for a job in its entirety, giving to subordinates the vision and capability for performance required. A most important aspect of the manager's job is decision-making, a task absorbing a very high proportion of his time and attention. The objective of "getting things done through people" can be reached only by decisions effectively communicated.

In making decisions the manager must see that adequate information is developed, if available. He must make prompt decisions which are accurate in terms of both short and long-range considerations. As a general proposition there are five phases to his decision-making:

- Defining the problem.
- Collecting and analyzing the facts of the problem.
- Developing alternate solutions.
- Selecting the one solution that best fits the circumstances.
- Putting that solution into action.

Usually these five steps are called the "scientific approach."

Management decisions must be developed in consonance with the objectives of the entire organization. There's no way to ignore the effect of today's poorly made decision. Inevitably, except by lucky chance, such decisions develop into "problem-children" of the future, for every management decision affects both the present and the future. The degree to which the future is affected determines largely the degree of risk that must be assumed. And, of course, it's the risk element that leads to worry and ulcers.

Management decisions may be recurrent or pretty much one-time in nature. In the case of recurrent decisions, the analysis and flow of information can be reduced to standard operating procedures, simplifying the task substantially. The seldom-made decision requires individual attention.

In the development of standard procedures for decision-making, the number of factors to be dealt with may become a problem. When the factors become sufficiently complex, electronic

First of a series

The Author

Gilbert Chester Jacobus is director of Field Operations, Army Logistics Research, and also on the School of Engineering faculty of George Washington University, Washington, D.C. He is also consultant on systems and management problems.

His degrees are from Rutgers University, a BS in civil engineering, 1929; New York University Business Administration, MBA, 1935; and Georgetown University, an LLB, 1950.

Before World War II, Jacobus was with New Jersey Bell Telephone Company. His war service included Intelligence Division of AEF in which he held the rank of colonel. He filled various postwar government executive posts in mobilization planning. In 1952-54, he was assistant Director for Emergency Planning, Public Affairs Office, FCDA, and director of instruction of The Army Command Management School the next two years.

He has received the Legion of Merit, the Order of the British Empire, and many other awards for his work with U. S. forces.

processing methods provide assistance. Such methods can be particularly helpful in ruling out unacceptable courses of action.

In determining the best solution, the manager's decision must be compounded from:

1. *Assessment of the risks involved.*

2. *Measures of resources and effort that will be consumed.*

3. *Recognition of timing needed.*

Operations Research, a new tool for decision-making, provides a means for appraising the balance of decisions; a means of testing decisions before putting them to work. This is accomplished through the construction of models which permit assessment of the result of varying degrees of emphasis on different factors incorporated within the model. The combination of emphases producing the optimum solution will prove out the best solution in terms of the factors considered. It's in this aspect that we often hear of the application of gaming techniques and electronic data processing techniques.

Management's Dilemma

The President of International Harvester Company has pointed out that ". . . the mechanics of running a business are really not very complicated, when you get down to essentials. You have to make some stuff and sell it to somebody for more than it cost you. That's about all there is to it, except for a few million details."

It's the details that kill us!

Top management, almost wholly divorced from direct contact with activities at the working level, finds itself depending upon a flow of information for knowledge of what's going on. Did I say flow? More often it's a flood. So how determine what's really meaningful? And this same dilemma is faced by many in responsible middle-management jobs.

Market analyses, operational engineering and other reports continuously are being fed to management. Studies come from time study experts, credit experts, industrial relations specialists and research scientists, from attorneys, economists, scientists. All the management man has to do is to understand how much emphasis to give each such specialty in formulating his decision, a step which affects simultaneously many or all of the specialist areas.

The impact of incorrect decisions, ill-considered decisions and misunderstood but sound decisions bears heaviest perhaps on middle-management people. Many such men haven't yet converted their point of view from that of the specialist to the generalist. Consequently, when a problem related to an individual's specialty arises, he comes up with a solution based primarily upon good practice within his own special field.

It may be that his recommendation goes up the line but higher management fails to adopt it. There may be two reasons for this. One is a failure to communicate adequately so that acceptance of the idea is created. The second is failure to take into account factors outside the specialty field.

In either case the middle management man becomes exasperated and grows to believe he's really not participating in managing the organization. In his own eyes he's ignored with no explanation.

Operations Research doesn't cure this automatically. It does provide a means whereby greater teamplay can be developed. Operations Research insists that entire problems be solved, not pieces of problems. Produce a solution that's best from the standpoint of all activities of the organization rather than sub-optimizing for any one part, or subordinate groups of activities.

At the level of top management, Operations Research is a very real aid in developing and maintaining the conceptual ability, which the top manager must add to his technical ability and the human relations ability acquired in the course of his experience.

What Opsearch Can Do

Operations Research was defined in 18 different ways in December 1955, ranging from "Operations Research is the science of decision-making" (R. W. Crawford, Monsanto Chemical Company)[1] to "Operations Research is the prediction and comparison of the values, effectiveness, and costs of a set of proposed specific courses of action involving man-machine systems, and is based on a model of the action which has been analytically described by a logical, and, when feasible, a mathematical methology; and which has had the values of the basic action parameters determined either from an historical analysis of past actions or from designed operations experiments. Most importantly, because all human and machine factors are meant to be included, an estimate of the uncertainty in the predicted outcome, and in the values, effectiveness, and costs of the proposed action, is provided." (Ellis A. Johnson, Operations Research Office).[2]

Whatever definition is accepted — and frequently definitions serve more to restrict than to promote thinking — there's ample evidence that Operations Research does aid managers who face tough decisions.

Operations Research in Industrial Decision-Making

An example of the kinds of problems that one company is tackling through Operations Research is a project to analyze the inventory and production control system in use at the Air Brake Division of Westinghouse Air Brake Company. The specific objectives of that project were to determine:

"a. When and how much to order for the manufacturing facilities;

"b. What factors control inventory investment and inventory shortages;

"c. The quantitative relationship between the control factors and what is being controlled;

"d. What the inventory investment should be normally or for any specified, acceptable level of shortages."[3]

It's interesting to note that in a discussion of an Operations Research project of the General Electric Company, the author states that:

". . . even the tentative results were better than anything then available to management as a basis for decision-making in the area involved. The results were used as recommended and the outcome that was forecast has occurred in the 18 months during which they have been used."[3]

Industry today is using Operations Research in such other studies as Distribution Analysis, Production Scheduling, Financial Analysis, Traffic Control, Machine Maintenance, Business Forecasting, and plant Lay-out. Systems analysis, Mathematical analysis, and other scientific techniques applied through Operations Research are leading to valuable solutions, providing very substantial progress.

---

[1] "What Is Operations Research?" by Anita R. Gardner, Industrial Editor, *Dun's Review and Modern Industry*, December 1955, Page 46.

[2] "Operations Research — Top Management Tool" by E. O. Boshell, Chairman and President, Westinghouse Air Brake Company, *Dun's Review and Modern Industry*, March 1956.

[3] "Allocation of Sales Effort in the Lamp Division of General Electric Company," Clark Waid, Donald F. Clark, and Russell L. Ackoff, *The Journal of The Operations Research Society*, December 1956, Page 629.

This is the first of three articles on this subject.

This method of coaxing ideas is like salting clouds to get a rain. They may not hit on targets but you'll more than likely get a shower — could bring down a cloudburst

BRAINSTORMING

Charles H. Clark

EVERYWHERE we look today we see an article on brainstorming. Here are a few recent articles that have appeared: *Factory Management* for May 1956; *Business Week*, December 29, 1956; *Time*, February 18, 1957. Not only are there a great many articles appearing but many companies are taking it up.

Fortune came out with a list of the 500 largest industrial corporations. Of the 10 largest in America, five are now active in this creative thinking and brainstorming including such companies as Standard Oil of New Jersey, General Motors, Ford, U. S. Steel, and General Electric.

To understand brainstorming we have to understand two principles of mental operation. We have two main types of mental process. One is the creative side of our minds. Suppose we symbolize this by the green, the GO sign.

As an example of creative thinking at work, consider the paper clip. Here is a small paper clip; here is a large paper clip. The man in New York who thought that up wrote me he sold one million of them at a dollar each one Christmas. Why didn't you or I think of that!

Here's another small idea that shows the creative mind at work — putting blood types on dog tags. Dr. Charles Bove, head of the American Hospital in France, was evacuated from Paris when the Germans took the city. In the south of France he helped in a military hospital. He wrote me "Strangely, this idea evolved in my head because I saw many battalions of wounded German soldiers, which I was told, were of the same blood group. As they had no tags to identify them, I wondered why." Small ideas can bear big consequences.

Not only do we have the creative side of our minds, the side that thinks things up but we also have the judicial side, the side that criticizes, the side that thinks things down. Let's symbolize this by the red, the STOP sign. As an example of the judicial side of our minds at work, let's take the zipper.

How did zippers come to be on men's trousers for flies instead of buttons? The story goes back to 1926, the state of Pennsylvania, at Meadville, the Hookless Fastener Company, now Talon.

A cub advertising salesman for the Saturday Evening Post working out of Philadelphia called on them one day.

"Art," they asked him, "How can we sell more of our zippers?"

"Where are you selling them now?" he replied.

"For tobacco pouches; Akron's beginning to buy them for footwear; they're beginning to put them on women's clothing."

Art thought a moment and said, "I've got an idea. Why not sell them to clothing manufacturers to put on trousers for flies instead of buttons?" They laughed at him. "That's silly — men won't like them – we'll run into trouble — we'll have lawsuits — it just can't be done."

Today you can hardly buy a pair of trousers without a zipper on them. It is one of their large markets.

How many months do you think it took that company to try out that simple idea which grealty increased their profits? In fact, how many years do you think it took that company before they even approached a clothing manufacturer with that simple idea. It took them *four* whole years before they even tried out that simple idea which put money into their pockets.

Our creative minds do not work in a straight logical order — part 1, part 2, part 3, part 4. Our creative minds work by a process of free association of the stream of consciousness so that part 1 leads to part 8 to 5 to 14 to 21, and so on. So we give our minds the green light, letting the ideas come as they want to; we go back later and apply judgment to put them into the best order for our purpose at hand.

How does all this work in a brainstorm?

Brainstorming is the name for a new type of problem-solving conference worked out by Alex Osborn, cofounder of the advertising agency, Baton, Barton, Durstine, and Osborn. Recommended number of people is 9-12, although as few as two people can follow the rules and get results. If there are more than 12, traffic jams can develop where everyone has to raise his hand to be heard. This slows up the pace. If there are too few people, the idea flow can come to a halt as there aren't enough minds to get a cross-stimulation of ideas.

We should have a specific target or question. There are two types of questions — the broad, general type and the limited, specific type. We call them the steamshovel-type question and the spade question. Experience shows that

Mr. Clark, who is on the public relations staff of Ethyl Corporation, gave this speech before an intensive 40-hour Creative Engineering Seminar, conducted by the U. S. Army Corps of Engineers, Research and Development Laboratories, Fort Belvoir, Virginia. We consider this the best short description of Brainstorming we have seen.

spade questions work best in brainstorms.

We should ask, "How can we improve the employee picnic?" not "How can we improve the employee morale?" We should ask, "How can we sell more motor oil at the pump island?" not "How can we sell more motor oil?"

Spade-type questions make it possible for all minds to focus on the same issue.

Let the people know about the problem two days in advance. Here is a sample invitation:

DATE
(Have it reach participants two days before meeting)

TO: Name of Participant

You are invited to a brainstorm on (date) at (place) at————p.m.

The problem is as follows:

How Can We Increase the "Sale" of Home Extension Telephones?

Extension telephones are available for any room in the house and cost either 70 or 80 cents a month plus an installation charge of about $2.50. Only about 16 percent of the home telephones now have an extension, and the company is interested in selling the first one to most customers and additional ones to old extension users.

Here are three examples of the kind of ideas we seek:

1. Give an extension to mother as a Christmas gift. (You pay for the installation and the first year's cost.)
2. Make an arrangement with carpenters or contractors who do game room or workshop construction in basements. Let them give you names of people who are installing those facilities so you can call and try to sell an extension telephone for that room.
3. Prepare a sales piece to send to people when they inform you that they are moving. Sell the idea of having an extension at the same time that the new telephone is put in. This will save an installation charge for the extension.

John Jones
Chairman

People then come up with some ideas and your meeting starts off in high gear. Be sure to give several ideas as a thought starter on your invitation. Do not give all your ideas in one category. If you list, "Give an extension to mother as a Christmas gift," do not have your other idea "Give an extension to children as birthday gifts" as it is the same category.

A brainstorm conference differs in one important respect from the average conference we are used to. In the average meeting someone presents a problem and someone suggests an idea. What happens? You can almost see the little red lamps of judgment lighting up as people come out with killer phases. Maybe you have heard some of them. "It can't be done." "It's against policy." "Our operation is different." Here is a list of a few such killer phases for killing ideas and chloroforming creative thinking in a conference. How many of them have you heard — or used?

A swell idea, but . . .
We've never done it that way
It won't work
It's not part of our job
We haven't the manpower
It's not in the budget
Too expensive
We've tried that before
Not ready for it yet
Good idea, but our plant is different

Mr. Osborn noted these phases popping up in meeting on sales problems in his ad agency. One day he hit upon a simple solution — give ideas the green light. Hold back criticism, suspend judgment, prevent debate and ridicule until *all* the ideas are out on the table.

You can't get hot water and cold water out of the same spigot at the same time. All you get is lukewarm water. In the same manner, you can't get hot ideas out of people's minds at the same time others are throwing cold water on them. All you get are lukewarm ideas. Get all ideas out, come back later and apply the red of judgment and pick out the good ones.

Brainstorming works because of a chain reaction. You may have had this experience. While a conference is going on, an idea pops into your head. You then look at your own idea with judgment. You decide it is in the direction of the target but it isn't such a good idea. You had better not express it right then, because someone will knock it to pieces. Ideas aren't born in our heads with all the armor plating of reasons why they're good, to defend themselves from killer phrases. So you decide you'll think about your idea and develop it later. So you walk out of the meeting with your idea in your head.

That will not happen to you in a brainstorm. The green light is up so you express your hunch. That gives someone else a little better idea. He tells his idea which gives someone a better one and we hit the target. But the whole chain reaction could not have been set off unless you had had the freedom to express your first small idea in the beginning.

In a brainstorm, we also try to improve and combine ideas. Sometimes a person lacks enough knowledge or experience to add a basic thought. However, they can improve or combine the ideas of others.

Take Walt Disney, for example. He's a genius. One of his lowest-paid artists came to him 14 years ago and said, "Mr. Disney, I think I can save you some money." He said, "How?" "I'm drawing these animal cartoons which go through the projector at a rate of 1016 frames per minute — so fast that no one notices the small details. Is there any good reason why I have to draw five fingers and five toes on all these animal creatures?"

Mr. Disney thought a minute and said, "No." So for the last 14 years they have saved thousands of dollars of art time by cutting back to four fingers and four toes.

We make use of the same principle in the brainstorm. The newest person is free to improve on the ideas of the genius.

What are some of the problems brainstorming has been worked on? It has worked successfully in many fields. Here are some typical problems:

"How to improve communications between the home office and the field."

"How to more readily detect hydrogen leaks in furnaces."

"How can brainstorming be used in the Army?"

"How to improve regional conventions."

You can get 80 to 100 ideas from a group of 12 in 30 to 45 minutes. BBD&O reports that six percent of their brainstorm ideas are useful. Your percentage should run 10 to 15 because an advertising agency uses only highly original ideas.

Now that you understand brainstorming, why not try it out? Follow Osborn's four rules (in table) and take a plunge. * * *

GROUND RULES FOR BRAINSTORM SESSIONS

1. ***Judicial judgment is ruled out!***
   Criticism of ideas must be withheld until later.
2. ***"Free wheeling" is welcomed!***
   The wilder the ideas the better; it is easier to tame down than to think up.
3. ***Quantity is wanted!***
   The greater the number of ideas, the more the likelihood of good ones.
4. ***Combination and improvement are sought!***
   In addition to contributing ideas of their own, panel members should suggest how suggestions by others could be turned into better ideas, or how two or more ideas could be combined into a still better idea.

THE CREED WE WORK BY—
A STATEMENT OF PRINCIPLES

Recognizing that business exists to serve the common good and appreciating that our stewardship is properly of broad interest to many people, we of Sun Oil Company wish to set forth the principles which guide us in the conduct of our business affairs.

We believe in America as a land able under God to enrich its people, both materially and spiritually, even more abundantly in the future than it has in the past.

We believe our company's principal role in America's future will be to develop petroleum and other energy resources, to process petroleum and related raw materials into high quality products for sale at competitive prices, and to provide such services as will help us to accomplish these ends most effectively.

We believe that the competitive system of free markets is the only effective regulator of economic enterprise, the only guarantor of efficient public service, and the indispensible protector not only of economic freedom but of all American freedom and opportunity.

We believe the opportunity to earn profits is the essential incentive to economic progress; that the ability to earn profits as a means of maintaining a sound financial structure, compensating stockholders for the use of their savings, and providing funds for growth to satisfy consumer demands, is the ultimate test of the real worth of a business to the people it serves.

We believe sound business and moral considerations dictate that we exercise integrity in all dealings with customers, employees, and stockholders, balancing the interests of each group so that all may share fairly, along with the general public, in the benefits to be derived from our business.

We believe in the right of employees to receive individual consideration and recognition, dignified treatment, and opportunity for self-improvement and advancement and, in addition, to negotiate collectively in their mutual interest.

We believe that stockholders, as the people who make our business possible through the investment of their savings, are entitled to a return at least equal to the return they might receive from other investments entailing similar risks.

We believe that the interests of customers, employees and stockholders alike dictate that we conduct all operations with the highest degree of efficiency, seeking constantly through training and the modernization of plants and equipment to reduce the cost of carrying out the functions in which we are engaged.

We believe the material well-being of the American people, as well as the strength of our Company, will in the future, as in the past, be largely dependent upon inventiveness; that prudence requires that we provide funds, facilities and talent for the vigorous pursuit of research in all aspects of our business.

We believe in being a good neighbor by doing our proportionate share, on the basis of ability, in whatever is good for the communities where we do business and by refraining from doing anything that is harmful or detrimental in those communities.

We believe in practicing economical use of natural resources to obtain the greatest possible benefit with the least possible waste.

We believe that in wartime the Military Forces must have prior claim upon our services and products and that our fullest resources must be dedicated to the common defense at such times.

We believe the attitudes of many groups and of the general public toward our business and the oil industry are important to our future; that their attitudes in the main reflect their knowledge or lack of knowledge of what we do and why. Consequently, it is prudent that we explain our business and account for our stewardship in order that people may hold informed opinions and reach wise decisions with respect to public policy as it affects our company and industry.

With these principles as our guides, we shall strive to manage our affairs so as to reflect credit upon our company, our industry and our country.

Sun Oil Company has published a booklet for its employees setting forth the company's principles of conduct and explaining how tradition was put into words and why the creed was published. This is a reprint of the creed. Sun would probably send a copy of the booklet upon request to its Philadelphia headquarters.

Every petroleum company is necessarily involved with national security and with U. S. military problems. Here is an opportunity to give some of your people a good background on problems industry is called upon to face for national defense. The Industrial College of the Armed Forces provides an opportunity to take a . . .

Short Course in Uncle Sam's Defenses

H. T. Deutermann

A NEW element of civilian participation in military affairs has developed in the last 50 years. This new element is the increasing dependence of the military forces on the civilian economy for support. Even minimum preparations for national defense involve so many people, so much material, and so much money that the entire economy is affected. Actual full-scale war in one way or another affects every person, every dollar, every factory, and every pound of material in the country.

For these reasons it is imperative that a great many people understand the problems inherent in mobilizing our economy for war and for the prevention of war.

This knowledge and understanding must not be confined to a few top-level military officers. Civilians, government officials, and reserve officers have, or will have, key positions in the mobilization of the economy.

For this reason the Industrial College has extended its educational facilities to those who cannot take the long resident course or enroll in the correspondence course.

Each year the college conducts a series of 16 National Resources Conferences in major industrial centers of the country. Each conference is a two-week session, five days a week, four hours each day, two in the morning and two in the afternoon.

These conferences are a very highly condensed version of the 10-month resident course. They outline the world situation and how it affects our national security. They describe in broad but easily understood terms the national resources, human, material and productive, which are the basis of our security and our position in world affairs.

The conferences do not attempt to "sell" any particular program, organization, or plan.

They are intended to be informative, to convey some important, provable facts, and to stimulate thinking about our security problems. Many of the problems covered are still to be solved. They will be solved only when an informed public opinion conveys the will of the people to our government leaders.

During the two weeks' conference, 32 lectures on the subjects shown below are delivered by a team of six officers from all the military services.

In addition to the lectures there are discussion periods on subjects of special importance and interest to conferees and a series of films pertinent to the subject matter. There are also extracurricular field trips to military installations and industrial plants.

Scope of Conference

ORIENTATION—An introduction to the objectives of the course, the material to be presented; the mechanics of the course, and the introduction of the faculty team members and Conference Administrator.

PUBLIC OPINION—The part played by public opinion in being a factor of economic strength is illustrated.

ORGANIZATION FOR NATIONAL SECURITY—A presentation of the present organization for National Security as developed in the Unification Act of 1947 and subsequent amendments; the factors which influenced the design and evolution of this organization.

WORLD HUMAN RESOURCES—A discussion of five basic *manpower principles*, followed by a resumé of the *world manpower situation* (Free World compared to Soviet Orbit). Emphasis on quality of manpower as an element of national power.

UNITED STATES HUMAN RESOURCES — A description of the major facets of *U. S. Manpower:* Supply, meeting demands against this supply, and utilization of this supply. Included is a discussion of the total population, the labor force, and sources of "extra" workers for the labor force; also the influence of health, education, and controls in manpower utilization.

TRANSPORTATION AND COMMUNICATIONS—A discussion of the role the transportation and communications industries play in the American economy in both peace and war. Some of the problems facing the industries and the mobilization planners in the event of an all-out emergency are presented.

POWERS AND FUELS—A summation of our country's position regarding its power resources; electric energy; coal, natural gas and petroleum as sources, and atomic energy.

STRATEGIC AND CRITICAL MATERIALS—A discussion of the mineral and material resources of the United States with emphasis on degree of self-sufficiency existing in such resources; means of improving supplies of materials, and prospects for the future.

AGRICULTURE—A study of American agriculture as a basic industry—its elements, economics, and its contribution to the economic potential of the United States and the Free World.

TECHNOLOGICAL PROGRESS—A discussion of the impact of technology on civilization; the research and development process; the effect of technological progress on social influences, and social implications; the United States position as a world leader in the technical field, and some of the problems to be encountered in keeping the valuable advantages we now possess.

REQUIREMENTS—A discussion of the different categories of requirements, problems involved in their determination, and current approach to minimize problems.

Rear Admiral H. T. Deutermann, USN, is Deputy Commandant, Industrial College of The Armed Forces, Washington, D. C.

PROCUREMENT—A discussion of procurement practices and procedures within the Armed Services and the legislation behind military procurement. It also covers the problems involved in contract placement, execution, renegotiation and termination, as well as an evaluation of the system from the standpoint of government economy and public convenience.

PRODUCTION—A discussion of some of the overall production problems that would arise in the event of a future all-out mobilization effort and the effect that the threat of atomic attack has on our planning for war production.

DISTRIBUTION—A discussion of the importance of logistics in supporting strategy and tactics; the elements of distribution; the magnitude and nature of distribution problems and operations.

SOVIET COMMUNISM — A discussion of communism, theory, development, practice, and application by the Soviets towards obtaining world-wide communism; of Marxism, Leninism, Stalinism and Khrushchevism; of the Soviet Government, constitution, the party, and the use of the political system as a vehicle for Communist party control; on the growth of communism in the United States.

WAR FINANCE—A discussion of the role of war finance in economic mobilization; the techniques and background; past and present experiences; conjecture about the future.

CIVIL DEFENSE—A discussion of the role of civil defense in minimizing the effects of a nuclear attack against the United States. Consideration is given to the strengths and weaknesses of our country. What civil defense is, what it can and cannot do, and some of the problems of keeping it alive. Discussion of results of atomic bombings and what we, as a nation, should do to protect ourselves.

MUTUAL SECURITY—A review of the background and development of the mutual security program, the status of the program, its achievements to date, and its significance as a part of the foreign policy of the United States.

EMERGENCY MANAGEMENT—A discussion of economic stabilization controls in time of emergency. A brief historical background of controls of World War I, World War II, and Korea, and a brief consideration of some of the difficulties of planning for future stabilization measures.

POSTATTACK CONSIDERATIONS — An analysis of the changed nature of war and a discussion of the new and complicated problems of nuclear warfare.

GEOPOLITICS — An evaluation of geopolitics as a theory of world power development; a discussion of the elements of national power and its relation to foreign policy; an estimate of Soviet geopolitics, and conclusions as to the value of geopolitics in the development of United States policy.

GEO-ECONOMICS — A review of the important aspects of the world economic situation and of their significance to the free world economic position.

LATIN AMERICA — An overall survey of the 20 countries comprising the Latin American area, with special emphasis on the economic, political, and military factors as they affect the economic potential of the United States and the Free World as a whole. Excluded from the discussion are foreign colonial possessions whose economies are oriented toward countries outside the area.

CANADA AND THE ARCTIC — An evaluation of the economic potential and strategic importance of Canada and the Arctic.

AFRICA — A survey of the strategic, economic, and political importance of Africa; its economic, social, and political problems and its contribution — actual and potential — to the world economy.

FAR EAST — A survey of the geographic, economic, and political factors which influence the economic potential of the Far East. Covered in the survey are the countries of China, including Tibet, Formosa, the Philippines, Korea and Japan.

SOUTH AND SOUTHEAST ASIA — An examination of the political, psychological and economic forces of the area, with particular consideration of its importance to the United States and the Free World.

MIDDLE EAST — An evaluation of the economic potential of the Middle East as a world area. A discussion of its *strategic location;* of its political, economic and military *weaknesses,* and of its *oil.*

FREE EUROPE — This presentation covers Free Europe, its political situation, its people and its economies, all from the point of view of its economic potential, and its possible contribution to the Free World.

SOVIET EUROPE — A survey of the political and economic forces of the Soviet satellite countries of Central and Eastern Europe, with particular reference to their economic importance to the Soviet Union.

SOVIET RUSSIA — A discussion of the USSR as a world power, the nation's geography, climatology, natural resources, and agriculture, manpower, and technological capabilities, industrial production; transportation, and economic war potential; planning measures used in the Soviet Union to achieve large scale industrial build-up, and evaluation of nearly 40 years under a planned economy.

SUMMATION — Review of objectives of National Resources Conference . . . the magnitude of the problem, the inseparability of the several parts of the problem, the global interrelationship of the factors and the importance of time. The part to be played by the leadership of the nation with respect to national security and the leadership of this nation in world security.

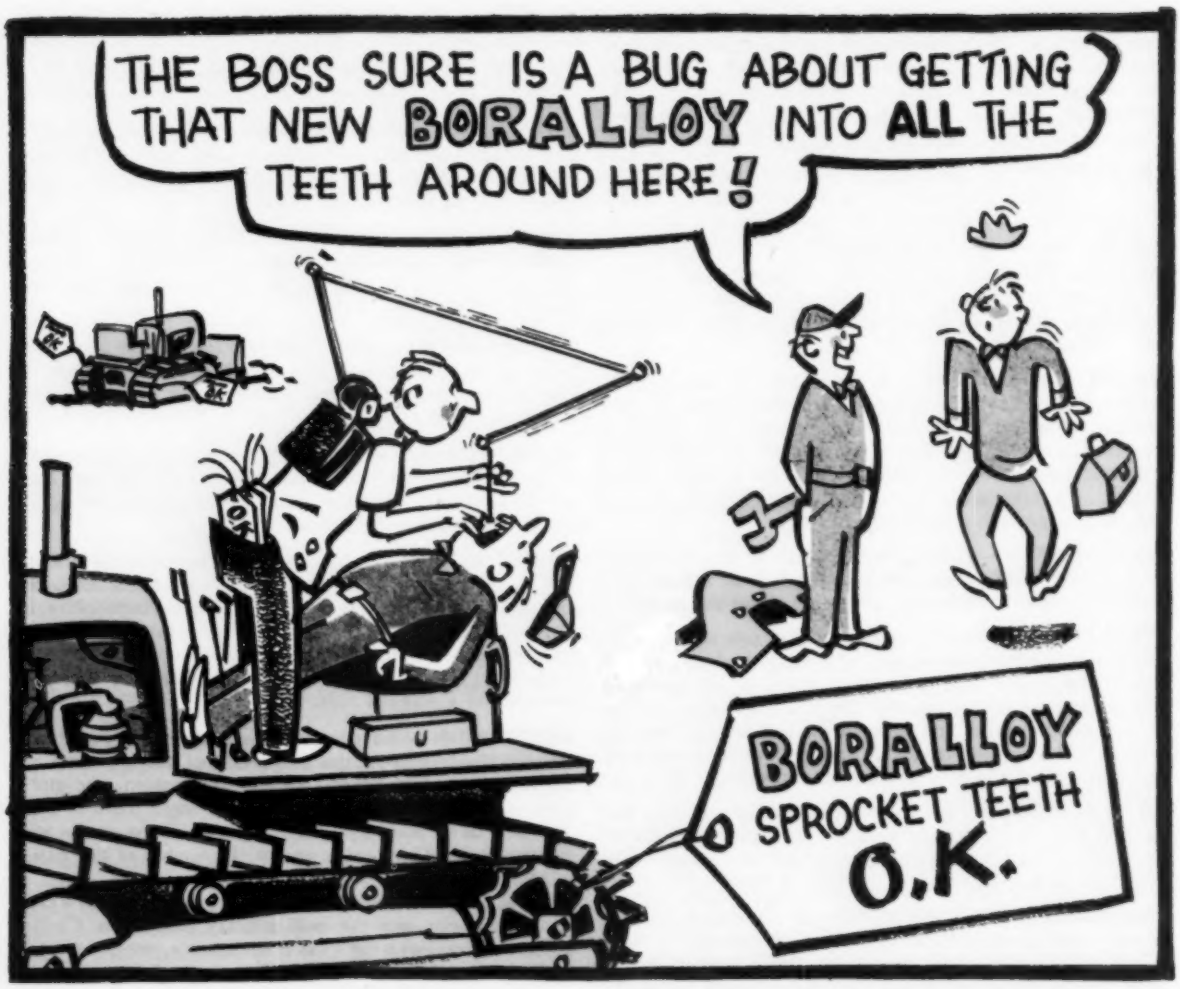
In each city the conferences are jointly sponsored by a civilian organization and the local military commands. Civilian conferees enroll with the local arrangements committee.

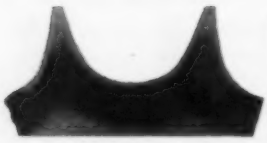
The Industrial College provides no funds to cover the expenses of the Conference and charges no fees.

Civilian committees are expected to make the arrangements for a suitable auditorium, printing, furnishings, and certain services. Determination of amount and collection of expense assessments from civilian conferees is entirely a civilian responsibility.

SCHEDULE OF NATIONAL RESOURCES CONFERENCES ACADEMIC YEAR 1957-1958

Burlington, Vermont	23 Sep.-4 Oct. 1957
Sioux Falls, South Dakota	23 Sep.-4 Oct. 1957
St. Louis, Missouri	21 Oct.-1 Nov. 1957
Boise, Idaho	21 Oct.-1 Nov. 1957
Pittsburgh, Pennsylvania	11 Nov.-22 Nov. 1957
Memphis, Tennessee	2 Dec.-13 Dec. 1957
Fresno, California	13 Jan.-24 Jan. 1958
Indianapolis, Indiana	13 Jan.-24 Jan. 1958
Los Angeles, California	10 Feb.-21 Feb. 1958
Boston, Massachusetts	10 Feb.-21 Feb. 1958
Charleston, West Virginia	17 Mar.-28 Mar. 1958
Philadelphia, Pennsylvania	17 Mar.-28 Mar. 1958
Rochester, New York	14 Apr.-25 Apr. 1958
Fort Worth, Texas	14 Apr.-25 Apr. 1958
Montgomery, Alabama	12 May-23 May 1958
Bridgeport, Connecticut	12 May-23 May 1958





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Result: CAT* BORALLOY sprocket teeth hold their contour longer. Teeth and track bushings *stay* in proper mesh, reducing wear and tear on all track running gear. Don't take chances. Get parts you can trust — see your Caterpillar Dealer today! Where else can you get the long-life benefits of Boralloy?

Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

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P 791.22

It costs $200,000 to replace a man in middle management . . . a top executive comes higher ... to find the right man, the executive should be . . .

Made to Measure

Stanley G. Dickinson

FINDING the right executive for the job and developing the right job for the executive are crucial skills which industry's top management still lack. This failure will continue to plague management men until they realize that as much concern must be given to *total* job training as to selection of executive material.

The tremendous cost of replacing management personnel is proof enough of the importance of making sure the employed executive is right for his job. In one corporation, for example, it costs about $6000 to replace a non-managerial employee, and $200,000 to replace a man in middle management. In the same corporation, direct and traceable replacement costs for a top executive exceeded $3,000,000. The astonishing fact is that it costs 500 times as much to have this executive fail as it costs to have one worker fail!

New demands upon today's executives are also exerting pressure on management to recognize the need for proper executive placement. Most corporation executives now face the challenge of mobility because of such rapid changes as acceleration, diversification, automation, merger or decentralization. Add to these the more personal problems that accompany these changes — for example, the transition from administrative to staff responsibility; from doing to delegating; and from self-reliance to dependence on others. Since the individual executive may fail at any one of these points, it becomes essential that management select its executives carefully, provide each executive with a clearly defined job and then train him well.

Is this the way corporations generally operate? In many cases the job is what the executive finds when he gets there, and the president and board feel, although with increasing uncertainty, that they have done their best when they promise him their backing. Later, management discovers that the executive cannot handle a part of his responsibility, so an assistant is appointed to compensate for that deficiency. Or perhaps the executive takes years to learn his job by trial and error when good training would have cut that time in half.

Even this rule-of-thumb selection has been largely to the good, as is indicated by the vitality and prosperity of American business. Were it not for the new and enlarged demands for executive mobility, we might be relatively satisfied with the result and hence deaf of pleas for improvement.

But improvement *is* needed now, and the first and crucial step is to clarify the function to be filled and then to create the organization to meet it. Top level management men have a common understanding of what they mean when they speak of vice president in charge of production or manufacture, finance or sales. But no single word conveys the function of bringing the right man to the right job. Perhaps we can agree upon a position of vice president in charge of management, somewhat comparable to the manager of a big league baseball club's farm system.

The climate in which such a man functions is all-important to his success. Free from any of the usual personnel manager's administrative duties, he must move in when there is difficulty in selecting the right man, and he should be active in providing adequate training in the new job. Operating in a solely consultative capacity, his job may require studying the Central Sales Division, where the turnover rate is costing the corporation $250,000 a year above average. Again, he may work with inner management while they pick someone to supervise the purchase of a new company, after which he may go to the new company and evaluate its job performance, selection and training standards.

Our newly created vice president should be able to answer at least six questions satisfactorily to be assured that his housekeeping is in order:

(1) Are the jobs well filled, at least at the manager and executive levels? To assure an affirmative answer, the responsibilities involved with each job should be clearly understood, and they should be such that the men ordinarily available can with reasonable effort fill the requirements. Standards of performance should emphasize what the corporation wants each man to do and on what basis he can expect recognition, compensation and promotion.

(2) Is genuine selection being practiced at the various levels? Good selection requires a delicate balance between scientific and performance tests and judgment. One of the most common mistakes is to give a testing division at headquarters the final authority on hiring and promotions.

(3) Is technical and on-the-job training carrying its share of the load? Too great a reliance upon some phase of training, especially upon pre-employment training or on-the-job training is a common error. Few corporations have satisfactorily resolved the question of what part of the training load is to be carried by texts, by supervised work projects, by pre-employment training, by class work, individual instruction, on-the-job training and refresher courses.

There are two simple methods to

Mr. Dickinson is a management consultant. This article by him was first published in *Challenge*, the Magazine of Economic Affairs, October, 1956.

determine training program failures. If the newly created vice president learns that a high percentage of those who fail in their jobs or are incompatible with immediate superiors seem to possess the same natural ingredients as those who succeed, he can with some assurance conclude that the training program is faulty. Or, an analysis of the time and level at which managers and executives reach plateaus in their effectiveness and a study of the difficulties encountered in getting them to rise from these plateaus might suggest a breakdown in some aspect of initial or refresher training.

(4) Are reservoirs of promotable candidates being built up? While regular job evaluations or fitness reports are common in business, the capable vice president in charge of management will ordinarily find no difficulty strengthening the system in use.

Appraise Personnel Limitations

Perhaps the greatest contribution our vice president can make is to appraise personnel limitations and then initiate action to overcome such difficulties. Consider, for example, the sales executive whose volume results are fine, but whose costs are too high, or whose men are mediocre. The time to catch and rectify such failings is when they are first noticed, not when the executive is vice president in charge of sales.

The story of an executive I know will illustrate the value of this kind of action. Starting as a salesman 25 years ago, he proved that he could sell a great quantity of goods, but his individual orders were small and he had too many returns and adjustments. As head of a team of salesmen, his record was the same — numerous, small orders and many returns. For the past 12 years he has been a sales executive in one of the corporation's 160 branches. Last year the hidden cost of handling his too-small orders and too-numerous refunds was $67,000 — more than enough to pay the salary of a new vice president.

(5) Are the little annoyances removed before they become big ones? What is the company's policy toward executives who refuse promotions? What does it do with those who think they should have been promoted? How are illusions, misconceptions, paternalism and bad promises eliminated? These little annoyances, of which every corporation has its share, can assume big proportions if ignored.

(6) Will top management stay in line? If high-placed executives are not always informed of the company's program for getting the right men and the right jobs together, the work of years can be undone by a speech, a private conversation or a chance remark. Conversely, with good staff work, the informed senior executive can greatly strengthen such programs.

The knowledge and techniques of specialists in many fields can be of immeasurable help in developing a full executive training and selection program. Competent economists, for instance, can contribute their talents by tracing to the corporation the cost of having employed improperly qualified executives. Beyond the simple, direct costs mentioned earlier, there are more subtle effects on stockholders, employees, the public in general as well as upon the quality of the product and its successful distribution. A team of psychologists and educators studying the circumstances under which executives hit a maximum of effectiveness can influence corporate policy. The medical men have a place in this, too, for one of the genuine problems in keeping the right man in the right job is that of preventing him from premature aging, physically or psychologically.

With this sort of expert help, we can count on the inherent good judgment of top executives to overcome present difficulties in the correct placement of executive personnel. ★ ★ ★

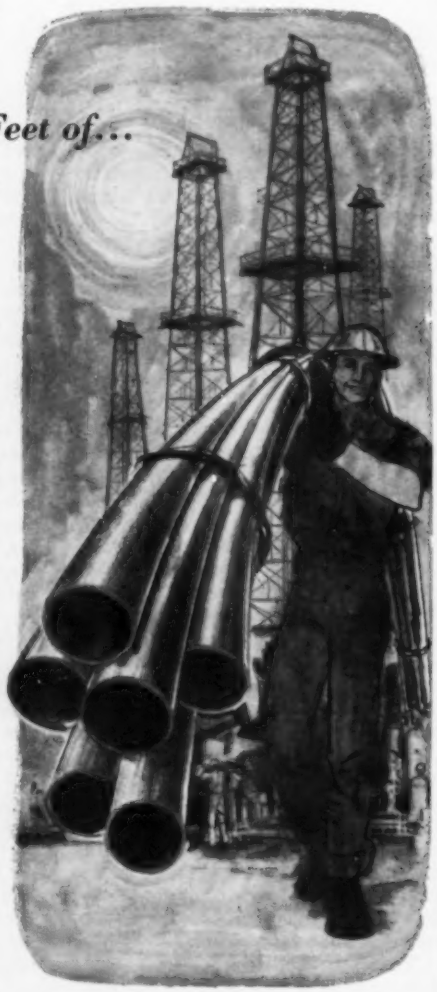
Over One Million Feet of...

KRALOY

HIGH-IMPACT

PVC PIPE

in oil-country use today



This proves that there is no substitute for Kraloy experience.

KRALOY is the most experienced manufacturer of PVC plastic pipe for the petroleum industry. The first polyvinyl chloride lead line installed in this country—at Great Bend, Kansas—was Kraloy Pipe. Kraloy High-Impact PVC today is preferred by production men for maintenance-free service in lead lines and disposal systems. Kraloy customers use Kraloy High-Impact PVC pipe for lead lines, gas lines, and salt water lines because Kraloy normally eliminates (1) sulphur corrosion due to sour crude, (2) paraffin buildup, (3) corrosion and scale, (4) trouble from soil electrolysis.

YOU Benefit From KRALOY'S Quality Control

To insure quality control, random samples of Kraloy Plastic Pipe are tested daily in Kraloy's own laboratory for burst pressure, impact resistance, and tensile strength under standard ASTM specifications.

Kraloy Pipe is Sold Only Through Qualified Supply Stores

Warehouse stocks and sales representatives:

Great Bend, Kansas:
Robinson Oilfield Specialties Co.,
616 Main St.

Houston, Texas:
The Mott Company,
1719 McKenney St.

Tulsa, Oklahoma:
The Becker Sales Company,
2837 Sands Spring Rd.

For case histories of actual Kraloy installations, cost comparison tables between Kraloy and other pipe, plus detailed instructions and specifications for all field uses, write to:

KRALOY *plastic pipe co., inc.*

4720 East Washington Boulevard, Los Angeles, Calif.

Subsidiary of the Seamless Rubber Co., a Rexall Drug Co. Subsidiary

KP-100

OIL AND GAS GATHERING LINES

gathering systems rely on Youngstown electric weld line pipe for long, trouble-free field performance

Youngstown Pipe has been used for 31 years in America's largest gas and oil field gathering systems. Quality-controlled through every production operation, it provides: Easy bending, uniform wall thickness, excellent line-up characteristics, outstanding weldability and longer lengths. Thus, Youngstown Line Pipe speeds and simplifies the laying of gathering lines.

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Producers of Carbon, Alloy and Yoloy Steels
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Engineers and their employers owe it to themselves to have a working knowledge of wage-hour rules... Litigation, damages, can result from inaccuracies

How do you solve that Overtime Question?

Robley D. Stevens

WHY make overtime pay more expensive than it already is? Your familiarity with the official simplified "tests" of duties, responsibilities, salary, and other basic requirements of eligibility for overtime exemption will keep overtime costs down.

The Fair Labor Standards Act states that anyone in your petroleum organization who is engaged in interstate commerce or in the production of goods for interstate commerce, including occupations closely related and directly essential to such production, must be paid overtime for work beyond 40 hours weekly.

Who in your petroleum organization is covered and who is not? Any one of the following workers can be sure that he is qualified for exemption by answering "yes" to the series of "tests" laid down in the wage-hour regulations, if their job measures up to all the requirements.

Three classifications of petroleum engineering personnel are presented below. It might be interesting to know just what each one is:

Dr. Stevens, now a management consultant in Washington, D. C., is a former official representative of the U. S. Department of Labor Research and Negotiations in all departments of government. A lawyer by profession, he is also an authority on labor relations; has several books to his credit on the subject.

PCA-56 (Rev. 1-57)
U. S. DEPARTMENT OF LABOR
WAGE AND HOUR AND PUBLIC CONTRACTS DIVISIONS

Form approved.
Bureau of the Budget No. 44-R1061.4

WAGE COMPUTATION AND TRANSCRIPTION SHEET

Date _____

Name of employee _____ Pay roll or card No. _____

Address _____

Occupation _____

Basis of payment _____

Establishment _____

Address _____

Contract Nos. (PCA) _____

(a)	(b)					(c)	(d)	(e)	(f)	(g)	(h)	(i)
Week Ending	Hours Worked				Total	Hourly Rate of Pay				Total Wages Paid	Total Hours Due	Total Due Worked

CLASSIFICATION 3

3. A professional petroleum engineer is one: (a) Who consistently exercises discretion and judgment, (b) does work that is mainly intellectual and varied as distinguished from routine and mechanical duties; (c) he spends no more than 20 percent of his workweek on activities not closely related to his professional duties; and, (d) earns at least $75 a week.

To be considered for the exemption as a learned professional, the employee's work must require advance knowledge in a field of science or learning, usually obtained by a long course of specialized intellectual instruction at a college or university. The mere possession of a degree does not automatically exempt the worker.

It is essential to consider the fact that the wage-hour regulations do not exempt all employees of professional employers, or all employees in industries having large number of professional workers, or employees in any particular occupation.

They do not exempt persons with professional training who are working in professional fields. The field of petroleum engineering has many persons with the title of "engineer" who are not professional engineers, as well as many who are trained in the engineering profession, but are actually working as trainees, junior engineers, or draftsmen.

It is natural for engineers working for a petroleum organization to *prefer* to be classified as professional workers and to be a part of the management team — most of them are. But it is not enough to be considered one in title alone. The job performance must meet all the "tests" prescribed for overtime exemption. Job titles are insufficient as yardsticks for exempting any individual worker from overtime pay after 40 hours weekly.

Equally important to consider is that the primary purpose of the exclusionary language — placing a limitation on the amount of non-exempt work — is to *distinguish* between the *bona fide* professional and the *working* engineering supervisor who regularly performs work only remotely related to the *supervisory* activities.

Record-Keeping

As executive, administrative and professional workers become available to your petroleum organization management, a foundation is laid for keeping certain time and pay records, which every employer in this industry must do. But, no particular form or order is required.

Based on past experience, the wage-hour records below should be kept for inspectional purposes. An investigator's first contact with an employer in this industry is through an audit of the records. Inaccurate or incomplete records could prove costly.

A simplified breakdown of the identifying information that should be kept in your records follows:

(a) Employees full name;

(b) His home address;

(c) His social security number;

(d) Occupation in which he is employed;

(e) Time of day and day of week his workweek begins;

(f) Total hours worked weekly;

(g) Basis of which wages are paid;

(h) Legal deductions from wages paid;

(i) Total wages paid each period;

(j) Date of payment and pay period covered by payment.

In the interest of sound petroleum management practices, these records should be kept. All records on which wage-hour computations are based. These items, which include time cards, wage-rate tables, worktime schedules, additions and deductions from wages, and including order, shipping and billing records should be kept two years.

All records must be open for official inspection when requested. An investigator may request your petroleum management to make extensions, recomputations, or transcriptions, as indicated on the illustrated Form FO-55.

The expanded coverage of the federal wage-hour law is strikingly pointed out by the fact that an employer in the petroleum industry might subject himself to litigation, criminal actions, or wage suits brought about by engineering personnel not found officially exempt by the inspector. Also, double damages are a probabiilty for the alleged back wages found due by the inspector.

Tips or complaints may arise from many sources — competitors, labor unions, employees, and ex-employees. Aside from this is the fact that a *reinspection* may occur at any time.

Overtime pay is expensive enough without making it more so by *misclassification* of your petroleum organization engineering personnel. The solution to this problem indicates that each management must of necessity work out its own system of compensation, consistent with the wage-hour regulations.

The foregoing suggestions are an important sampling of the many things to consider when qualifying your petroleum engineering workers for the exemption status. It is obvious from all this that both employer and employee alike owe it to themselves to have a working knowledge of the wage-hour exemption rules. ★ ★ ★

REPORTS OF PERFORMANCE

from users during the past 16 years show that Kennametal* lasts 20 times longer than steel and 3 to 5 times longer than special and super alloys.

• A Texas producer reported sand abrasion forced a pulling job every 14 to 20 days. After 448 days on the job, Kennametal Balls and Seats showed no wear when well was pulled for other than valve job.

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Kennametal API Balls and Seats are available at repair shops of most major pump manufacturers. Ask your service man to standardize on them. They'll cost you less in the long run. KENNAMETAL INC., Latrobe, Pennsylvania.

*Kennametal is the Registered Trademark of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.

Fifth of a Series

LSU Offers Specially Designed Courses

Management training for a particular company can be set up at Louisiana State

James W. Reddoch

RAPID economic development now taking place in Louisiana and surrounding states has placed an additional responsibility of adult education on Louisiana State University. In no area is this responsibility greater than in the field of Business Management.

In a talk before the Baton Rouge Rotary Club in February, Dean William D. Ross of the College of Commerce stated, "The need for upgrading business management in this country is tremendous. The College of Commerce of Louisiana State University is cognizant of this need and is willing to enter into a partnership with business and industry to meet this need. The College of Commerce can help through its undergraduate and graduate program and also by offering management training and development courses for men in supervisory, middle, and upper management positions."

Excellent facilities have been made available for this purpose by the University. Ruffin Pleasant Hall is assigned for exclusive use of the General Extension Division. The division, under the direction of Dr. J. W. Brouillette, is in charge of coordinating all short courses, conferences, and other adult training programs conducted on this campus. Pleasant Hall has 180 hotel-like rooms and can accommodate approximately 425 adults. Cost to people taking part in short courses is $2.50 per night.

Class and conference rooms are also available in the building. These rooms seat from 20 to 250. Some are air-conditioned. Larger group meetings can be held in other air-conditioned rooms on the campus.

Management development courses offered by the College of Commerce in cooperation with the General Extension Division and other colleges on the campus may be divided into two broad classes.

One type can be classified as annual conferences devoted to a particular phase of management. An excellent example of this type of training program is the annual Louisiana Personnel Management Conference. It was organized under the direction of Professor Karl D. Reyer in 1940.

This two-day conference, held each spring, attracts participants from a wide geographic area. Most of the speakers are men and women of national reputation from the fields of higher education and industry. The conference is under the supervision of Dr. Leon Megginson, associate professor of Business Administration. Attendance at the February 1957 conference was over 300. Registration fee, which includes copy of proceedings, is $15.

The second type is management development courses designed to provide intensive "tailor-made" one-week short courses to fit the needs of individual firms, groups, and organizations. A typical example is a short course recently completed by six groups of management personnel of Gulf States Utilities Company of Louisiana and Texas.

This course was developed to give training in the subjects mentioned in the table.

A total of 148 supervisors, department managers, local superintendents, and district superintendents participated. Each group spent a full week on the campus and received 37 hours of formal instruction. Four evening meetings were also held, which were handled by company officials and were devoted to company policies and history. Seven professors in the College of Commerce were used in this course, and six professors were drawn from other colleges of the University, three from the College of Arts and Sciences, two from Industrial Education, and one from the Law School.

In computing the fee to be charged for these short courses an attempt is made to arrive at an amount which will cover the out-of-pocket cost to the Uni-Industrial Education, and one from the Law School.

Other specific programs, such as four to six-week executive development courses for both middle and upper management, are contemplated. Inquiries should be addressed to: Dean William D. Ross, College of Commerce, Louisiana State University, Baton Rouge, Louisiana. ★ ★ ★

Mr. Reddoch is acting head, Department of Business Administration, Louisiana State University, Baton Rouge 3, Louisiana.

GULF STATES UTILITIES COMPANY
SHORT COURSE FOR SUPERVISORS, DEPARTMENT MANAGERS, LOCAL SUPERINTENDENTS, AND DISTRICT SUPERINTENDENTS

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
8:00	Yarbrough Overview Supervision	Hauer Supervision	Hauer Supervision	Hauer Supervision	Yarbrough Supervision	Lesikar Written Communications
9:00	Ross Economics	Ross Economics	Payne Economics	Sliger Economics	Schur Economics	Yarbrough Supervision
10:00	Pellegrin Industrial Sociology	Pellegrin Industrial Sociology	Pellegrin Industrial Sociology	Pellegrin Industrial Sociology	Pellegrin Industrial Sociology	—
11:00	Braden Oral Communications	Braden Oral Communications	Braden Oral Communications	Braden Oral Communications	Braden Oral Communications	—
Noon	Lunch	Lunch	Lunch	Lunch	Lunch	—
1:30	Young Industrial Psychology	Young Industrial Psychology	Young Industrial Psychology	Young Industrial Psychology	Young Industrial Psychology	—
2:30	Reynard Labor Law	Reynard Labor Law	Reynard Labor Law	Reynard Labor Law	Reynard Labor Law	—
3:30	Reddoch Public Relations	Reddoch Public Relations	Reddoch Community Relations	Megginson Personnel Management	Megginson Personnel Management	—

Six Groups: Dec. 3-8, 1956; Dec. 10-15, 1956; Jan. 7-12, 1957; Jan. 14-19, 1957; Feb. 11-16, 1957; Feb. 18-23, 1957

6:30 p.m.—Dinner Hatcher Hall, except Wednesdays. Evening meetings— Company policies and history.

Management Personals

L. W. Moore is the new president of American Oil Company, subsidiary of Standard Oil (Indiana). Moore, formerly executive vice president, succeeds **Donald J. Smith,** who has retired.

L. W. Moore

S. K. McCauley

Samuel K. McCauley, The Atlantic Refining Company, was elected president of Iricon Agency Ltd., suceeding **John W. Gendron,** Tidewater Oil Company.

Iricon represents the five percent interest in the Iranian Oil Consortium held by American Independent Oil Company, Getty Oil Company, Hancock Oil Company, Richfield Oil Corporation, San Jacinto Petroleum Corporation, Signal Oil & Gas Company and The Standard Oil Company (Ohio) as well as Tidewater and Atlantic. Other newly elected officers include: **A. H. Elliot** of Iricon's London office, executive vice president; **David E. Day,** Richfield, and **R. S. Stewart,** Sohio, vice presidents; **C. F. Krug,** Getty, treasurer; **Harley C. Stevens,** AIOC, assistant treasurer; **Harold A. Black,** Los Angeles, secretary and general counsel, **John K. Schemmer,** San Jacinto, assistant secretary. **Benjamin Tyran,** AIOC, **B. H. Dresser,** Hancock, and **F. D. Lortscher,** Signal, were elected to the board of directors.

J. R. Hurley, assistant to the supplies manager of Shell Oil Company's transportation and supplies department, was named to a company position in Calgary, Canada. He will assume duties as crude oil representative in exploration and production. Hurley succeeds **R. L. Hope,** who, after a period of training in California, will assume Hurley's duties in Shell's New York offices. In the interim, **L. E. McGongile,** manager of Shell's San Francisco products department, will temporarily take over Hurley's duties in New York.

Monroe J. Rathbone, president of the Standard Oil Company of New Jersey, has been named president of the Lehigh University board of trustees. Rathbone succeeds **Eugene C. Grace,** chairman of Bethlehem Steel Company, who resigned. **Leonard M. Horton,** vice president, Aubrey G. Lanston & Company Inc., was elected a corporate trustee of the university to succeed **Nevin E. Funk,** retired vice president of the Philadelphia Electric Company.

L. F. McCollum, president of Continental Oil Company, has been honored for "meritorious achievement in the field of management-stockholder relations" by United Shareholders of America, Inc. The award is known as the 1956-57 United Shareholders of America Annual Meeting Award.

Sidney M. Witt retired as tax counsel for Sunray Mid-Continent Oil Company. He will continue to serve the company in an advisory capacity.

Edward D. Mellinger was appointed editor of the American Petroleum Institute *Quarterly*. Mellinger, who had been serving as consulting editor, succeeds **Walter Henry Nelson,** who has resigned.

Claud B. Barrett, formerly vice president for The Texas Company at Houston, Texas, becomes senior vice president and chief executive officer at Houston. **Everett R. Filley,** formerly vice president in charge of the producing department - domestic, becomes senior vice president in charge of Texaco's world wide producing interests and activities. **Theodore A. Mangelsdorf,** formerly vice president, becomes senior vice president in charge of the company's worldwide refining interests and activities. **James T. Wood Jr.,** formerly vice president at Los Angeles, becomes senior vice president and chief executive officer at Los Angeles. **J. B. Christian,** formerly chairman of the board and managing director of Trinidad Oil Company, Ltd., a Texaco subsidiary, becomes vice president in charge of Trinidad operations, with headquarters in New York. **L. C. Kemp Jr.,** formerly general manager of Texaco's petrochemical department, becomes vice president in charge of that department. **J. Howard Rambin Jr.,** formerly assistant to the vice president in charge of the producing department-domestic, succeeds Filley as vice president in charge of that department.

John H. Dea was named assistant to the president. He has been assistant manager of the sales division of Texaco's foreign operations department-Western Hemisphere and West Africa.

C. B. Barrett

E. R. Filley

T. A. Mangelsdorf

J. T. Wood Jr.

L. C. Kemp Jr.

J. H. Rambin Jr.

J. H. Dea

O. P. Puryear was named assistant manager, laboratory operations, technical services division, at the Texaco Research Center, Beacon, New York. He was formerly regional manager, technical services division, Houston, Texas.

James A. Rapalje, a recent graduate of Lehigh University, has joined Texaco as an engineer; **Joseph P. Fagan,** a recent graduate of Boston College, as a chemist, and **N. Bruce White,** a recent graduate of the University of Vermont, as an engineer.

A. W. Vitt was appointed general manager of the western division of Seaboard Oil Company.

Charles E. Simons, Dallas, Texas, executive vice president of the Texas Mid-Continent Oil & Gas Association, was appointed to the Trade and Professional Association Committee of the United States Chamber of Commerce.

Paul J. Anderson has been appointed senior representative in the United Kingdom for Standard Oil Company (New Jersey), and will continue to serve as Middle East representative. Anderson succeeds **H. W. Fisher** who is assuming new responsibilities as joint managing director of Iraq Petroleum Company and associated companies.

Kenneth H. Faulk was appointed section leader of the special projects section of the Cities Service Research and Development Company's Process Research Laboratory at Lake Charles, Louisiana.

Jesse L. Childers is in charge of the office of the Standard Oil Company law department that will serve Kansas, Missouri, and Oklahoma and is assisted by **Walter R. Lethem Jr.**

Harry M. Schafer was named manager of supply for Union Oil Company of California. Prior to this appointment Schafer was manager of distribution for Union's extensive southwest marketing territory.

Englehardt August Eckhardt, formerly vice president in charge of research for the Gulf Research and Development Company, has been appointed assistant director of the National Science Foundation for the Division of Mathematical, Physical, and Engineering Sciences. **Raymond J. Seeger,** who has filled the position in an acting capacity, will continue as deputy assistant director for the division.

Kenneth E. Manner was appointed assistant secretary for Cities Service Gas Company. He recently joined the company as an assistant to the secretary.

K. E. Manner

W. L. Nelson

The 1957 Award of Merit of the American Association of Cost Engineers was awarded to **Wilbur L. Nelson** during the annual meeting held at the University of New Hampshire.

12,000 hp needs a lot of cooling!

One of six Young HC® 1415 units used to cool six 2,000 hp Ingersoll Rand Compressor engines at the new American Louisiana Pipeline Company's compressor station at Defiance, Ohio.

Young DOES THE JOB at this new compressor station

The entire cycle of cooling the engine jacket water and lube oil is automatic; each unit being complete with shutters automatically controlling the fan motors.

Wherever there are "big names" in industry you will find, with increasing frequency, Young heat transfer equipment in operation either as standard units or designed to meet specific requirements of an installation.

If you have a heat transfer problem contact your nearest Young Radiator Company representative — see yellow pages of your telephone book — or write to Young Radiator Company, Dept. 217-H, Racine, Wis. There is no obligation.

OIL FIELD and PIPELINE REPRESENTATIVES

1. Central Station Equipment Co. Tucson, Arizona
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7. H. J. Young Muskegon, Mich.

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Young RADIATOR COMPANY

RACINE, WISCONSIN

Creative HEAT TRANSFER ENGINEERS

Executive Office: Racine, Wisconsin, Plants at Racine, Wisconsin, Matteon, Illinois

Personals

James N. Landis was nominated president of The American Society of Mechanical Engineers. He will be installed during the ASME annual meeting to be held in New York in December. Landis is vice president of Bechtel Corporation and a past chairman of both the San Francisco section of ASME and of its Metropolitan section in New York.

Others named were: **Charles E. Crede,** vice president, Barry Controls, Inc., Watertown, Massachusetts, vice president region I. **Arthur W. Weber,** vice president, Corning Glass Works, Corning, New York, vice president region III. **Ernst W. Allardt,** chief engineer, The Babcock & Wilcox Company, Alliance, Ohio, vice president region V. **Henry S. Aurand,** lieutenant general, U. S. Army, Ret., Honolulu, Territory of Hawaii, vice president region VII. **L. N. Rowley Jr.,** Editor, *Power,* McGraw-Hill Publishing Company, New York, director-administrative activities. **Elmer O. Bergman,** staff consultant, C. F. Braun & Co., Alhambra, California, director-codes & standards. **Ronald B. Smith,** vice president, The M. W. Kellogg Company, New York, New York, director-technological activities.

John E. Harris Jr. was named manager and **H. J. Horsch** assistant manager of the newly created supply division of Phillips Petroleum Company's supply and transportation department, Bartlesville, Oklahoma. The new supply division combines the former crude oil supply division, which was headed by Harris, and the products supply division, which was managed by Horsch. **John L. Kyser,** formerly coordinator, is promoted to assistant to the manager of the supply and transportation department, **H. J. Classick,** promoted to coordinator, and is succeeded as assistant coordinator by **R. M. Berner.**

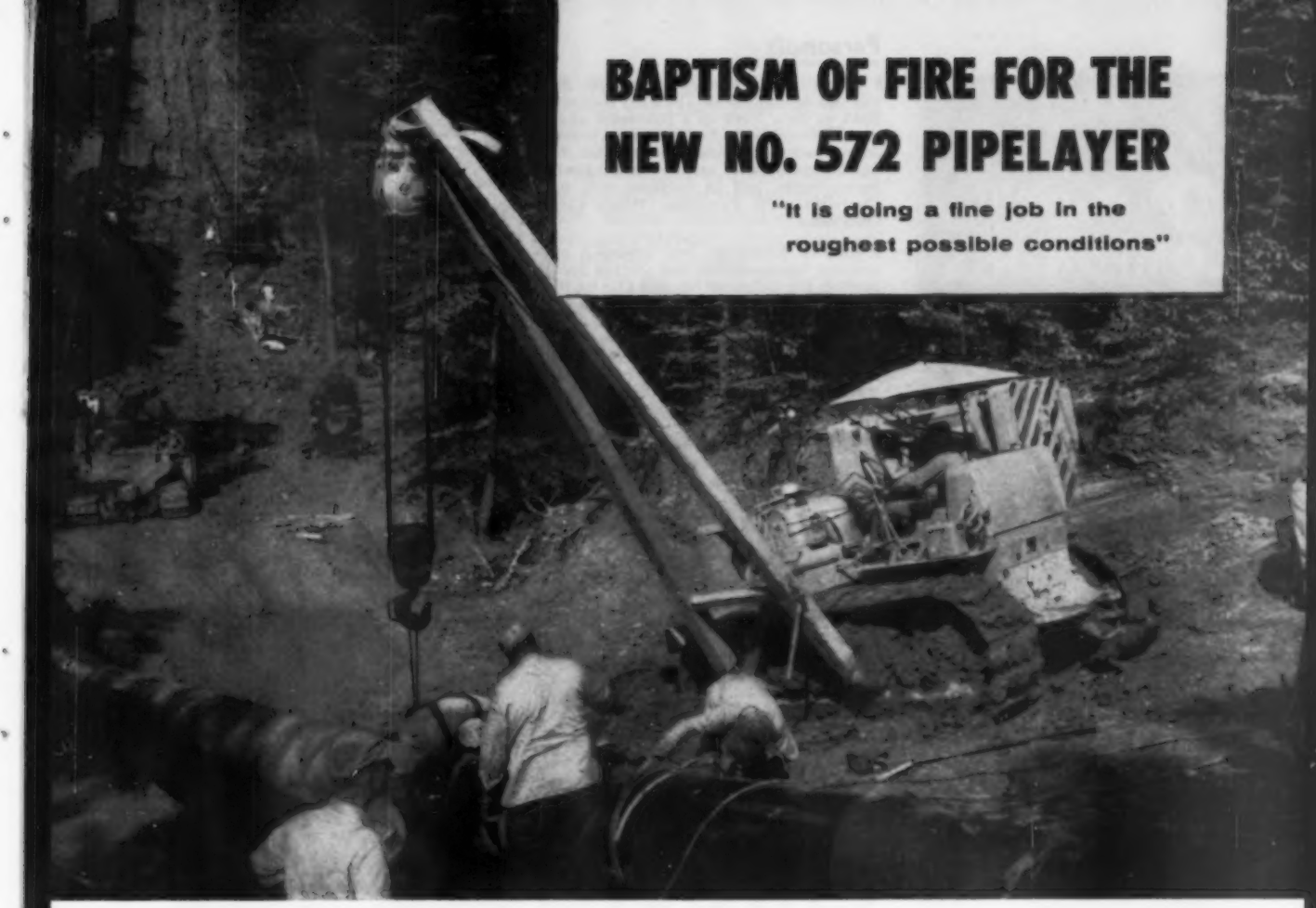
Robert L. Minckler, president of the General Petroleum Corporation, will be one of the principal speakers for the annual convention of the Association of Desk and Derrick Clubs of North America August 30 and 31. He will speak on the subject "American Business Creed."

J. A. Vickers, president, The Vickers Petroleum Co., Inc., was commissioned by Governor George Docking to serve on the Governor's Oil Advisory Committee for the State of Kansas.

Oscar B. Schier, II, was designated secretary-elect of The American Society of Mechanical Engineers by unanimous vote of the Society's Council. He succeeds **Clarence E. Davies** who retired.

T. A. van Griethuysen was elected president and a director of Continental Oil Company of Venezuela. **Charlton Kerr,** a member of Conoco's geophysical staff for almost 20 years, was elected vice president, exploration manager and a director of Continental Oil Company of Venezuela. He will continue to make his headquarters in Caracas. **H. R. Wall** was promoted to general manager of Continental Oil Company's transportation and supplies department, succeeding van Griethuysen. Formerly manager of manufacturing for Conoco's southern and southwestern regions, he will continue to make his headquarters in Houston, Texas. **D. W. Sims,** who has been general purchasing agent, will continue as general purchasing agent, with headquarters at Ponca City.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



BAPTISM OF FIRE FOR THE NEW NO. 572 PIPELAYER

"It is doing a fine job in the roughest possible conditions"

There was no gentle break-in period for the new 86,000-lb.-capacity Caterpillar No. 572 Pipelayer announced in April. On one of its first jobs, it was thrust into steep, mountainous terrain, made slick and dangerous by continual rain, near Elkins, W.Va. How's it doing? Here's the answer from Ralph Gaddy, spread superintendent of Williams-Austin Co., Pittsburgh.

"It is doing a fine job in the roughest possible conditions. The design is right and the engineering is of the best."

On this rough-and-rugged job, the CAT* No. 572 Pipelayer is laying 8½ miles of 26-inch gas line for Columbia Gas System. The line will parallel an existing line starting at the Files' Creek Compressor Station.

This pipelayer needed no babying because it is the product of extensive field tests. It was engineered to produce wherever big-inch takes you. With its 19-inch ground clearance and its 86-inch track gauge, the No. 572 gives you stability in any type of terrain. And it is powered by a dependable Cat Diesel Engine rated at 128 HP at 1,200 RPM.

Operators can work at top efficiency, because the unit was designed to make their job easier and safer. The No. 572 has in-seat starting. Controls are located for convenience and positioned for frequency of use.

Here's the perfect machine to team up with the 130,000-lb.-capacity No. 583. Call your Caterpillar Dealer soon. He'll demonstrate it on *your* job . . . at *your* convenience.

Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

WANTED—THE HARD WORK

Personals

Richard R. Newton has joined the petroleum department of The First National Bank of New York as a petroleum engineer. Previously he has been a corporate officer and a petroleum engineer for the Smith Newton Oil Company in Bradford, Pennsylvania, and an engineer with the Continental Oil Company, Ponca City, Oklahoma.

Earl G. Ellerbrake was named a petroleum transportation and storage specialist in the Office of Oil and Gas of the Department of the Interior. Prior to entering Federal service, Ellerbrake's professional career was spent in the oil industry with the Standard Oil Company (Ohio) and its subsidiary, Sohio Pipe Line Company.

DEATHS

Samuel K. C. Kopper, assistant to the chairman of the board of directors of the Arabian American Oil Company, died in his sleep at his home in Larchmont, New York. He was 42 years old.

Irving W. Reynolds, 77, vice president of The Foxboro Company, died June 3 of a heart attack at his home in Foxboro, Massachusetts.

Hilmer F. Peterson died of leukemia Thursday night, June 13. He was manager of Shell Oil Company's Pacific Coast area survey and drafting department.

Byron Miller (Cap) Smith, 44, executive vice president of Leland Equipment Company of Tulsa, Oklahoma, died upon arrival at a Tulsa hospital on June 13 of an apparent heart attack.

Birt H. Mills, 94, former Tulsa oil lease dealer died in Tulsa June 2.

James Emmett Jr., 50, vice president in charge of sales for Jas. P. Marsh Corporation, Skokie, Illinois, died June 7 of a heart attack.

I. W. "Jack" Wheland, 57, long-time oil man in the Midwest, died May 29 in Grand Rapids, Michigan. He had been ill for several months.

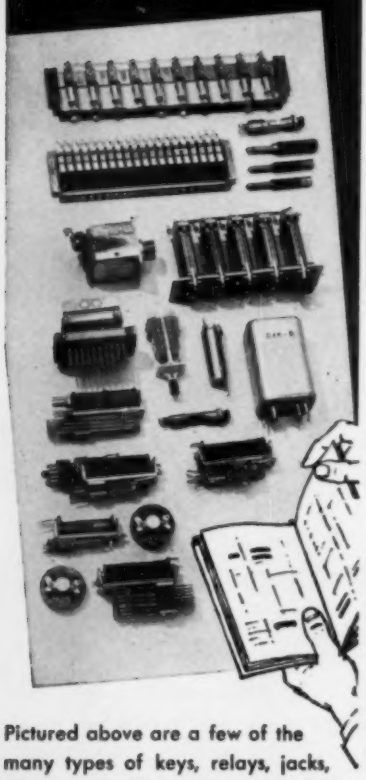
Harry T. Paterson, 46, operational manager of the Harbor Island and Kure Beach corrosion test stations of The International Nickel Company, Inc., died suddenly at his home May 27.

T. J. Sullivan died suddenly May 28. Sullivan, 64, was a senior vice president of Gulf Oil Corporation. He headed Gulf's manufacturing department from 1949 until 1955 when he was designated senior vice president responsible for Gulf's manufacturing operations on a world-wide basis.

Edward Leon McDowd, 63, retired former chief scout for Shell Oil Company in the Los Angeles area, died May 23. McDowd retired in 1954 after 21 years service with Shell, the last ten as chief scout.

W. T. Stevenson suffered a fatal heart attack at his home at Owensboro, Kentucky, on May 22, 1957. He was president of Texas Gas Transmission Corporation, chairman of the board of directors of its wholly-owned production subsidiary, Texas Gas Exploration Corporation, president of Western Kentucky Gas Company, and president of its wholly-owned L-P gas subsidiary, Kengas, Inc.

which of these quality **COMPONENTS** *do you need?*



Pictured above are a few of the many types of keys, relays, jacks, plugs, and other components which Kellogg supplies to industry. 60 Years of experience stands behind the reliability of these important parts. Write today for your Kellogg Industrial Catalog.

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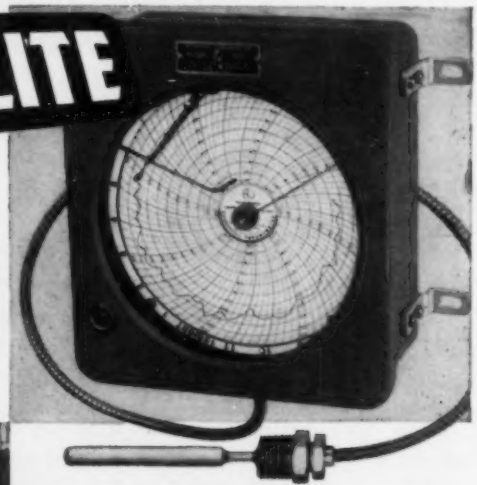
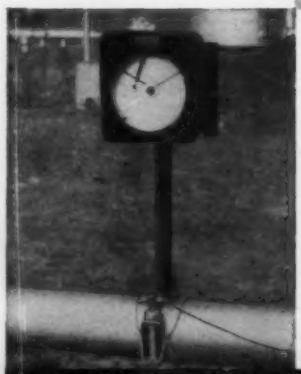


. . . for TEMPERATURE RECORDING . . .

One of the many uses for Auto-Lite Recorders is the application shown below . . . a natural gas field meter run.



Auto-Lite Model "1000" Temperature Recorder has 6" chart. Various standard ranges from minus 40° F to plus 550° F. Available for wall mounting, portable or portable self contained use. Electric or mechanical chart drive. Choice of 24-hr. or 7-day cycle. Capillary tubing permits remote reading. Priced as low as $49.50. Manufactured to customers' specifications. Send for latest Catalog describing many types of Auto-Lite Recorders and Indicators.

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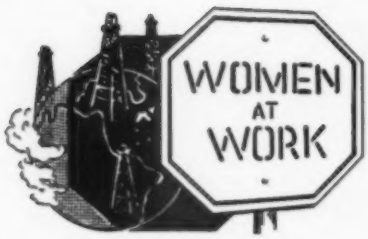

Corporate Officer

Ruth Thomas Hunter is a Mid-Continent product. She was born in Kansas, reared in Oklahoma, and has become a successful business executive in Texas. She went to school at St. Joseph's Academy, Guthrie, Oklahoma, and went to elementary and high school in Oklahoma City.

Starting with Houston Production Company over 25 years ago as a plain, "garden variety" stenographer (as she phrases it), Ruth became a director of

Ruth Hunter

the company in 1950. She has served as secretary-treasurer and purchasing agent for the past 19 years.

Ruth is now a contact between the field operations and the officers and directors of the company. She is subject to call day or night and takes weekly trips to the field, located in Liberty County, Texas.

Aside from her work, which is Ruth's "pet" project, her hobbies are many, including books, music, light operas, and the Little Theatre Guild. She is very interested in the Bluebird Cerebral Palsy Clinic, sponsored by the Bluebird Circle of the First Methodist Church, and the Cerebral Palsy Treatment Center, which is a project of the Soroptimist Club of Houston, in which she serves as a director. She is also a member of the Desk & Derrick Club and IPAA.

Having traveled quite a lot over the United States, South America, and Europe, she hopes now to make a trip around the world some day, and we are sure she will!

48 Years Service

"First woman employed by Bovaird and Seyfang Manufacturing Company" is a distinction held by **Kathleen Wade** of Bradford, Pennsylvania. Upon her retirement as general accountant in 1954, she had completed 48 years of continuous service, lacking only two for a golden celebration.

In 1905 she assumed her first stenographic duties with Bovaird and Seyfang, following graduation from St. Bernard's High School. As the company progressed, so did Kathleen. Named general accountant in 1924, she recalled those early days as busy, what with shipping engines and boilers

Kathleen Wade

to all parts of the world. She remembers the building of a complete refinery in Japan, and the heavy shipments to the new oil fields of the Southwest.

The daughter of an old Bradford family, Miss Wade has always been active in community life. She is an officer of the Desk and Derrick Club, and is active in the Catholic Church. Her experience, knowledge and understanding were relied upon by the Office Angles, an organization of Bovaird and Seyfang woman.

The company advises that she surely is missed, but Kathleen reports she hasn't had time to be lonely. Many plans and dreams which had to wait over the years are becoming reality.

Taxes Are Her Forte

From the bookkeeping department to her present position as secretary-treasurer is the progress made by **Julie Mueller.** Introduced to the oil industry in 1947, she joined the Terminal Drilling and Production Company, Los Angeles, California, owned and operated by Emmett H. Jones. Since, she has worked her way up to secretary-treasurer of all of his corporations.

Julie reports that her work touches on most of the company's activities, which include all phases of drilling contracting and maintenance work, as well as wildcatting and producing operations in the Rocky Mountains, Texas and California. Since it has been a most pleasant and gratifying association, Julie feels she is one of the lucky "women at work."

Julie Mueller

Taxes and corporate law have been her specialty and each year she attends the Federal Tax Institute held by the law school of University of Southern California. Additionally, for the past four years, Julie has been taking preparatory studies for CPA examinations.

A busy family, with two children, aged six and eight, has pretty well taken up her outside activity time. Husband Gene has been with Gulf Oil Corporation and active in other phases of the industry for several years. Their daughter, Debbie, starred in the General Electric television series "The Money Maker" and son, Dennis, is an ardent Scout.

Esther Shelberg is one of the four employees of Phillips Petroleum Company whose service goes back to the day when the company incorporated in June 1917. She symbolically cuts the 40th anniversary cake with a cake knife and cake server made of the firm's newest product, Marlex 50, a new rigid polyethylene plastic. Phillips, first U. S. company to develop and commercialize a process for rigid polyethylene, went into a large scale production of Marlex 50 plastic in its plant near Houston, Texas, early this year. A number of major plastics manufacturers are about to announce consumer items made of this polyethylene.

Books to Read

Properties of Petroleum Reservoir Fluids, *by Emil J. Burcik, published by John Wiley & Sons, Inc., 440-4th Ave., New York 16, New York. Pages, 190, Price $7.50.*

This book contains an outstanding description of the properties of petroleum and gases which make up reservoir fluids and describes in logical sequence these concepts in so far as a reservoir fluid is concerned under the pressures and temperatures which are encountered. It describes not only the properties of ideal fluids but presents impirical correlations which may be readily used in the solution of the complex system which are encountered in the petroleum reservoir work.

The Public Speaker's Treasure Chest, *by Herbert V. Prochnow, published by Harper & Brothers, 49 East 33rd Street, New York 16, New York. Pages, 413. Price, $3.95.*

This book is claimed to be the only one of its kind and will be found quite useful by every person who writes and delivers an occasional speech whether it be in a civic association, a club or a speech before a technical meeting. It's filled with hundreds of ideas on how to give your speeches more sparkle.

Index is arranged to help you in getting material on any given subject, be it on a famous man, restaurants, politicians, writers or salesmen. It will be an invaluable aid to you regardless of where or to whom you might speak.

Chemical Engineering Kinetics, *by J. M. Smith, Professor of Chemical Engineering, Purdue University, published by McGraw-Hill Book Company, Inc. 330 West 42nd Street, New York 36, New York. Pages 402. Price, $8.00.*

This text is designed for students and practicing engineers, giving the background needed for the design, construction and operation of reaction equipment. The text capably combines theory with practice, devotes chapters to design of batch reactors, flow reactors, semibatch reactors and gas-solid catalytic reactors.

Catalysts, Volume 4, *Hydrocarbon Synthesis, Hydrogenation and Cyclization, edited by Paul H. Emmett, published by Reinhold Publishing Corporation, 430 Park Avenue, New York 22, New York. Pages, 570. Price, $12.50.*

The eight chapters of this text have been contributed by six outstanding authors in the field of physical chemistry of catalysis and catalytic processing. The first four chapters are devoted specifically to the Fischer-Tropsch Synthesis, including Thermodynamics of the Hydrogenation of Carbon Monoxide, Catalysts for the Fischer-Tropsch Synthesis, Kinetics and Reaction Mechanism, and Crystalline Phases and Their Relation to Fischer-Tropsch Catalysts. The remaining four chapters follow quite naturally from the first four, discussing isosynthesis of hydrocarbons and oxygenated compounds, methanation, and catalytic cyclization and aromatization.

Valency and Molecular Structure, *by E. Cartmell and G. W. A. Fowles, published by Academic Press Inc., 111 Fifth Avenue, New York 3, New York. Pages, 255. Price, $5.80.*

This book is intended to fulfill the need for an introductory text in which an elementary account of the development of the quantum theory is combined with the survey of its application to structural chemistry. First explaining quantum theory and atomic structure, the book presents mathematical techniques, with the non-mathematician in mind.

Guide to Instrumentation Literature, *by W. G. Brombacher, Julian F. Smith, and Lyman M. Van der Pyl, National Bureau of Standards Circular 567, 156 pages, $1.00. (Order from Government Printing Office, Washington, D. C.).*

This circular is intended to assist research investigators, instrument users, and others interested in utilizing the extensive and scattered literature of instrumentation. It was prepared as part of the program of instrumentation research and development which is cooperatively sponsored at the National Bureau of Standards by the Atomic Energy Commission, the Office of Naval Research, and the Air Research and Development Command.

Effective Communication on the Job, *edited by M. Joseph Dooher and Vivienne Marquis, published by American Management Association, 1515 Broadway, New York, 36, New York. Pages, 294. Price, $5.50.*

This is one of American Management Association's business books which can almost be called handbooks. The sub-title is "A Guide to Employee Communication for Supervisors and Executives" and it is exactly that. Edited by M. Joseph Dooher and Vivienne Marquis, it covers effectively the methods of communication beginning with its place in the management job down to how to manage your talk.

The Push-Button World: Automation Today, *edited by E. M. Hugh-Jones, published by University of Oklahoma Press, Norman, Oklahoma. Pages, 176. Price, $3.75.*

Like other technical developments of the present age, automation is not "just around the corner"; it is already upon us. But the public, which stands to gain immeasurably from it, knows little about its implications; and management and labor, which will be increasingly involved in the revolution in production it provokes, have scarcely had time to adjust to the radical new ways of thinking called for by automation.

The Petroleum Refinery Engineer's Handbook, *by J. F. Stachan. Philosophical Library, Inc., 15 East 40th Street, New York 16, New York. Pages, 168. Price $15.*

A more practical title for this text would be "Refinery Equipment Inspection Techniques." Its chapters discuss organization and procedures for refinery equipment inspection departments, with specialized sections on specific types of refining units and processes. A chapter is also devoted to corrosion and its prevention.

Management in Action, *by Lawrence A. Appley, published by American Management Association, 1515 Broadway, Times Square, New York 36, New York. Pages 382. Price $5.00.*

As nearly everybody knows, Lawrence A. Appley is president of American Management Association, probably at this moment the fastest growing organization in the country. All of a sudden American management became concerned about its duties and responsibilities and its succession. Lawrence Appley and his organization have been the answer as well as an inspiration to that trend.

Sub-title of this volume is "The art of getting things done through people." In its own review of the book the American Management Association says that "Mr. Appley has applied the experience of the operating executive and the knowledge and insight of the social scientist to arrive at answers that are significant to everyone who 'gets things done through people.'"

"Management in Action" is a forthright and comprehensive discussion. Any person in management or with ambitions to be a manager, should read it. In a way it is a textbook for good managers.

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LAUGH with BARNEY

A Frenchman was traveling around the U. S. on a goodwill tour. The first place he stopped was in a small town in Virginia and in his bedroom was a sign saying "George Washington slept here." He asked about the sign and was told that Washington is known as the father of our country.

As he traveled across the country he found many more of the same signs. In fact, nearly every hotel he stayed in had a similar sign.

When he returned to Washington, D. C., to make his report, it included the candid comment: "I can certainly see why George Washington is known as the father of your country."

Mazie: You've been stenographer for nearly all the big shots in this department haven't you?

Mabel: Yes, I'm just about on my last lap now.

Biggest problems for traffic planners are urban, suburban, and bourbon drivers.

Don: "Do you know what good clean fun is?"

Lynn: "No, what good is it?"

About the only thing you can look down on and approve of at the same time is a plunging neckline.

A woman without principle usually draws considerable interest.

"The traps on this course are very annoying," observed a member of the golfing foursome.

The one who was putting raised his head.

"They certainly are," he commented. "Would you mind shutting yours?"

A snobbish rich man drove up to the front of a hotel in a Ford Thunderbird. The colored door man gave him a parking check for the car and got in to drive it away.

"Do you know how to handle these high powered cars?" the snob snapped.

"Yass sir," he grinned, I sho do — it's just a little ole Fode."

If you think Barney is a little dull — send your own jokes to: Barney, Box 1589, Dallas 21, Texas.

"I'm anxious to make this shot. That's my mother-in-law up on the clubhouse porch."

"Don't be a fool. You can't hit her at 200 yards."

Little William had been late to school for the past week and when he came in Friday morning at 10:30 the teacher just threw up her hands.

"What's your excuse this morning? And I want the truth. Why are you so late?" the teacher asked.

"Well," stalled William, shuffling his feet, "Last night Dad heard something out in the chicken yard. He got out of bed, picked up his gun and lantern, and without his clothes on he went out to the chicken yard. He put the lantern down and stooped over to look into the chicken house and old Rover cold-nosed him. I've been picking chickens all morning."

A landman and a geologist, on their way out to a rig, stopped and bought a few beers to take along. The landman put the beers in his briefcase and they resumed their driving. After a few miles the geologists asked if the beers might get hot since it was a very hot day. The landman replied: "Couldn't possibly, they're surrounded by cold deals!"

Do you know the definition of a redhead — A communist outhouse.

There was a young woman who had so many children that she didn't know what to do, and another coming; so, she went to the doctor and said, "Doctor, I keep having children; I don't know what to do." He studied her a moment and then said, "You must take three aspirins." And she said, "When, before or after?" And he said, "Instead."

The origin of the expression, "hurrah for our side!" goes back to the crowds lining the streets when Lady Godiva made her famous sidesaddle ride through the streets of Coventry.

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SALT WATER DISPOSAL

and WATER FLOODING

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Engineered for long service, Line Scale Valves and Seats are ideal for all reciprocating pumps . . . regardless of size, age or model . . . in Bronze and Stainless steel, they meet every need at pressures up to 1,500 P. S. I. and temperatures up to 300° F. Special sizes on request.

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The Trade PARADE

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Association Condemns Racing

The board of directors of the Automobile Manufacturers Association unanimously recommended to member companies that they take no part in automobile racing or other competitive events involving tests of speed and that they refrain from suggesting speed in passenger car advertising or publicity.

The board voiced the desire of automobile manufacturers to "encourage owners and drivers to evaluate passenger cars in terms of useful power and ability to afford safe, reliable and comfortable transportation, rather than in terms of capacity for speed."

The resolution recommended that member passenger car manufacturers:

1. Not participate in any public, competitive test of passenger cars involving or suggesting racing or speed, including acceleration tests.
2. Not encourage or assist employees, dealers or others, or furnish financial, engineering, manufacturing, advertising or public relations assistance in connection with any such event, directly or indirectly.
3. Not supply "pace cars" or "official cars" in connection with any such event.
4. Not advertise or publicize any such event or the results thereof, or assist and encourage others to do so.
5. Not advertise or publicize actual or comparative capabilities of passenger cars for speed.

Fibercast open house. Over 300 purchasing agents, engineers and production management personnel from the Mid-continent area attended an open house at the Fibercast Corporation plant in Sand Springs, Oklahoma. Occasion was the completion of new facilities at the plant. Guests were taken in groups through the step-by-step manufacture of Fibercast line pipe and well tubing. One of the groups shown going through the plant include (left to right) F. M. Mayer, president of Continental-Emsco Company, Byron Appleton, D. W. Sims, Austin Cartright, Harold Johnson and Bill Lee all of Continental Oil Company and R. A. Brewer, division manager of Continental-Emsco Company.

Master Tank Opens in Quincy

A "Fourth of July" atmosphere prevailed at the Open House of Master Tank & Welding Company in Quincy, Illinois, as fire fighting and fire prevention methods were demonstrated by the Bureau of Mines and Ansul Chemical Company. Vivid demonstrations were given of the causes of LP Gas, wood and gasoline fires and the latest extinguishing techniques were applied. Event was the opening of new LPG tank manufacturing facilities by the company at Quincy, Illinois. Visitors toured the 15,000 sq ft plant which houses the most advance equipment for the manufacture of propane tanks.

Multi-linqual Computers

An electronic computer has been programmed to interpret four foreign languages and automatically type out idiomatic English translations.

Peter Toma, 32-year-old Hungarian technician at the California Institute of Technology, fed a Datatron electronic computer four excerpts in Russian, French, German and Spanish. One was a headline from *Pravda*—"Mashina perevodit s odnovo yazeeka na drugoy." Datatron flashed its neon lights and printed on an electric typewriter the precise English equivalent: "Machine translates from one language into another."

According to Toma, this marks the first real breakthrough toward a universal interpretation of all the world's tongues—and a common written language. His is the only technique formulated for multiple-language machine translation.

Demonstration was held by the Electro-Data Division of Burroughs Corporation, Pasadena, which manufactures the Datatron computer system.

To prime his electronic linguist, Toma first transmitted to its magnetic memory drum four specially-condensed dictionaries of Russian, French, German, and Spanish. These had been punched on paper tape in numerical computer language, along with instructions telling Datatron how it should go about translating.

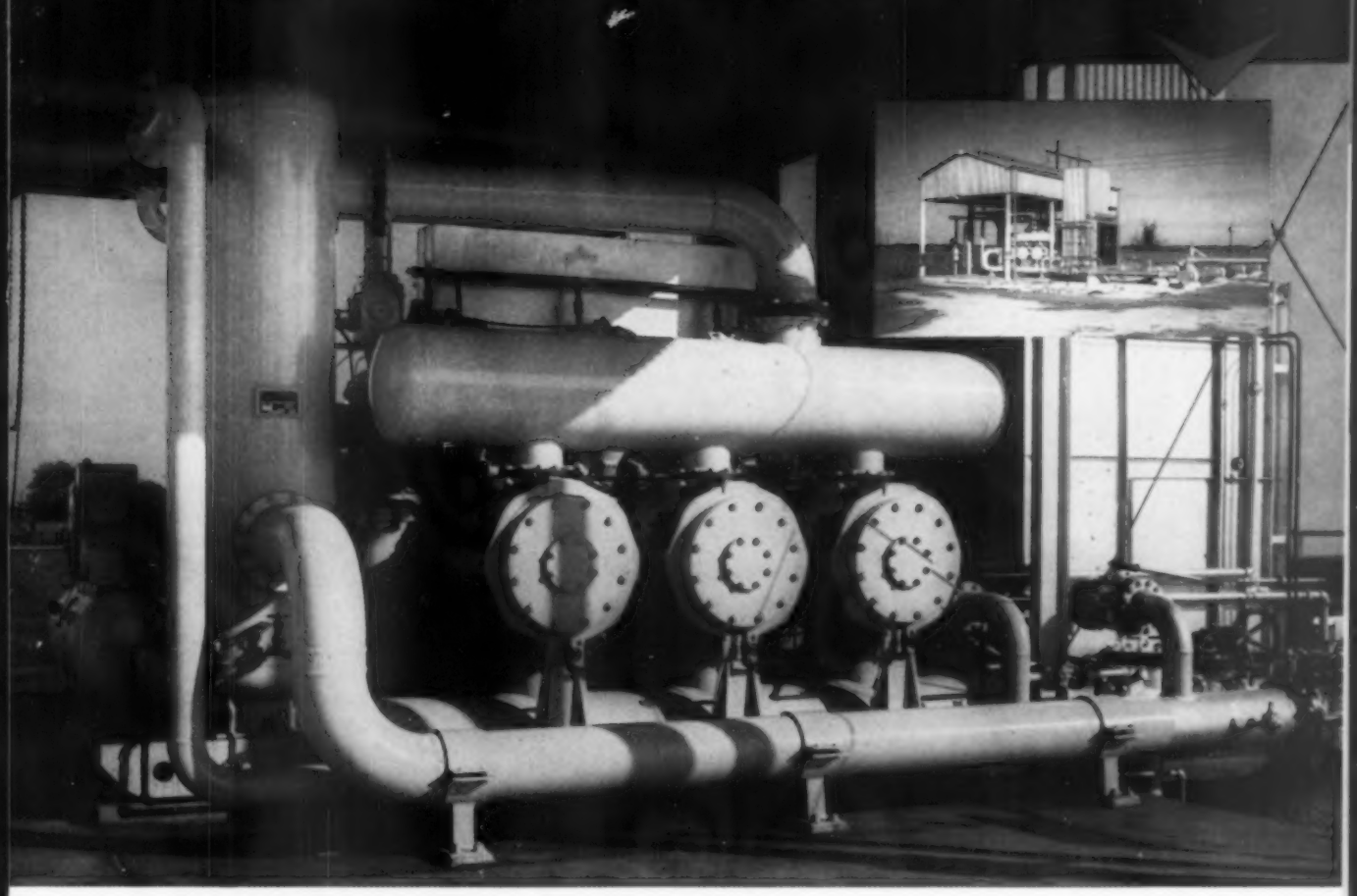
Garrett Oil Tools Opens New Plant

The new plant of Garrett Oil Tools, Inc., division of U. S. Industries, Inc., was formally opened with a plant tour and luncheon attended by the U. S. Industries, Inc., board of directors and officers, Garrett officials and prominent guests.

Installation is located on a 40-acre tract, east of Longview on U. S. Highway 80 and has a total building space of 86,000 sq ft. An interconnected administration section and shop comprise the main building. Research and engineering functions are conducted in a separate building of similar construction. Offices, drafting room, experimental machine shop and a 1000 ft-test well are housed in this building.

INCREASED ENGINEERING AND construction operations in Canada have resulted in the expansion of Stone & Webster Canada Limited in Toronto. Initially the new facilities will provide for a design and drafting group, but these will be expanded as rapidly as conditions permit to a fully integrated engineering, design and construction organization.

BEAIRD-INGERSOLL-RAND Packaged Compressor Plant



UNITED GAS PIPELINE COMPANY'S Monroe Field Station No. 1 equipped with a Beaird-Ingersoll-Rand 6SVG 330 h. p. packaged compressor complete with all necessary controls for unattended operation. Other sizes from 120 to 660 h. p.

Unattended Operation-

HIGH VOLUME BOOSTER STATION

BEAIRD
another AMF product
PACKAGED COMPRESSOR PLANTS

LOWEST COST PER HORSEPOWER INSTALLED

UNITED GAS PIPELINE COMPANY has installed this Compressor Station near Sterlington, Louisiana. Equipped with a Beaird-Ingersoll-Rand 6SVG 330 h.p. packaged compressor, the station is an integral part of United's Monroe Field facilities. Gas from declining wells in the field are boosted from 10 psig to main line pressure of 25 psig. Ten million cubic feet per day are handled by this single Beaird unit.

Designed for unattended operation, the compressor is equipped with regulators that enable the driving engine to throttle from half to full speed to maintain constant discharge pressure. Should operating conditions become less stable, compressor valve unloaders can be installed which will provide completely automatic operating control. The compressor will then unload its cylinders in steps, maintaining precision discharge pressure to the main line. When the condition causing the pressure build-up is eliminated, the unit would automatically close the unloading valves and pick up the required load.

Let us show you how a Beaird-Ingersoll-Rand packaged compressor plant can be designed to meet your special requirements.

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Shreveport, Louisiana
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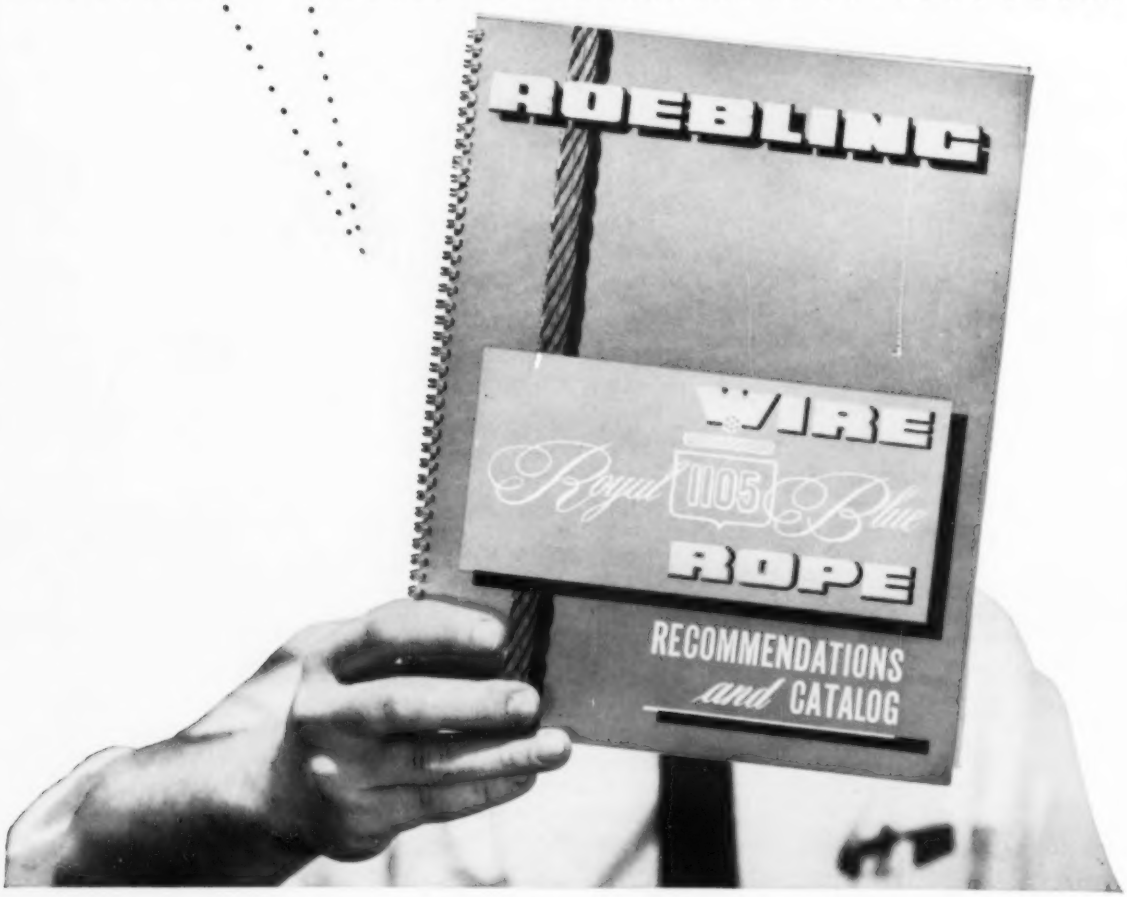

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Alten Expands Texas Operations

A series of moves to enlarge Alten's Texas activities was announced recently by Warren M. Benson, vice president of Alten Foundry & Machine Works, Inc. W. B. "Bill" Hudson, formerly Alten's North Texas representative, Jacksboro,

Bill Hudson

Harold Newlon

has been named Texas district manager. Hudson moved to Odessa where he will have his headquarters and supervise the opening of a new Alten warehouse. Harold E. Newlon has been appointed to replace Hudson in the North Texas area.

PEOPLE

Two appointments to new positions in the Shreveport area have been announced by Hycalog, Inc., Shreveport. **W. W. Bynum,** vice president, has been promoted to vice president in charge of sales and service for well logging, "Spectra-Scan" logging and field gas recording. **James Woods** has been promoted to vice president in charge of sales and service for diamond coring, core analysis, diamond bits, drill bits, diamond core barrels and parts.

Baker Oil Tools, Inc., has announced the appointment of **E. H. (Hubie) Clark** to chief research engineer. With Baker for 10 years Clark has served as assistant chief research engineer for the past 4 years.

E. H. Clark

F. C. Smith Jr.

Frank C. Smith Jr. has been named general sales manager of Southwestern Industrial Electronics Company of Houston, Texas, one of the Dresser Industries. He will be responsible for SIE geophysical, test instrument and control equipment sales.

E. L. Miller

R. L. Boyer

Eugene L. Miller has been elected president and general manager of The Cooper-Bessemer Corporation. He formerly was assistant general manager. At 38, Miller is the youngest president the company has had. Other personnnel changes are: **Ralph L. Boyer,** elected to vice president and director of engineering; **Frank J. Hunter,** promoted to branch manager for the St. Louis and Kansas City areas; **Arthur Abel Jr.,** appointed district manager for the Tulsa office. **Hewitt A. Gehres,** former vice president and director has retired after serving 41 years with Cooper-Bessemer. **W. S. Arthur** has retired after nearly 50 years service with the company. **B. L. Potter,** after 44 years with the company, has also retired.

F. J. Hunter

H. A. Gehres

W. S. Arthur

R. L. Daniels

Roger L. Daniels has been advanced to chief engineer of the Formsprag Company, Detroit.

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LAST 10 TIMES LONGER

Stitt "X" Type Sour Gas plugs resist corrosive action of sour gas — last months longer — require fewer changes — cut "down" time. It's not the plug price, but the "change cost" that's important! Stitts cost a little more — save hundreds of dollars per engine per year. Factory equipment in Clark, Cooper-Bessemer, Worthington, other leading engines.

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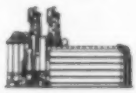
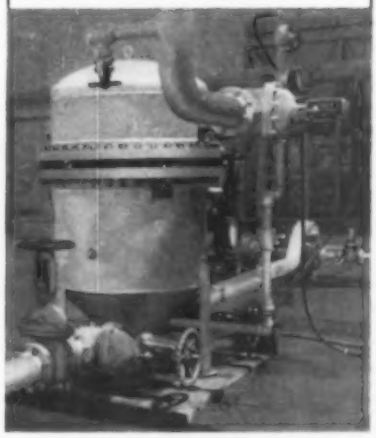
— at less cost





only STELLAR® FILTERS give you all these advantages —

1. Removal of finest solid corrosion products
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4. Exclusive gas-bump cleaning eliminates backwashing, simplifies waste disposal
5. Shortest off-stream time for cleaning
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These and other important advantages are inherent in the distinctive design of the "STELLAR" filter, for conservation of your amine solutions. Write today for complete information and Bulletin No. 1560-B.

Inquiries and samples are invited on all problems in the treatment of waters and wastes for the petroleum and related industries.

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THE ONLY COMPANY impartially offering equipment for ALL types of water and waste processing: coagulation, precipitation, sedimentation, flotation, filtration, ion exchange and biological treatment.

57403-A

Trade Parade

The Continental-Emsco Company has announced the appointment of **T. A. Ramey** to assistant manager of the export division, New York City. **Ramon H. Robinson** was named to the post of manager,

T. A. Ramey

R. H. Robinson

distributor department in Dallas. Ramey joined Emsco Manufacturing Company in 1953 as sales manager for drilling machinery at the Dallas office. With the recent consolidation of Continental Supply Company and Emsco Manufacturing Company, he was appointed manager of distributor sales. Robinson was named distributor machinery specialist for Continental-Emsco on January 1. He joined Emsco Manufacturing Company as a service engineer in 1947. In 1950, Robinson was promoted to machinery salesman and served in this position until the two companies consolidated.

Otis Engineering Corporation has transferred **W. K. (Jug) Waters,** division manager for the firm in Corpus Christi, to its South American subsidiary, Servicio Tecnico de Pozos "Otis" C. A. in Maracaibo. A veteran of many years' service with Otis, Waters was assigned to the firm's New Iberia, Odessa, and Oklahoma City divisions in various managerial capacities. He was also stationed in the company's home offices and manufacturing plant in Dallas. **Bob Crain,** veteran manager of Otis' Oklahoma City division, has been transferred to Corpus Christi as division manager. **Duane Johnson,** superintendent for the Otis division in New Iberia, has been promoted to district manager in Oklahoma City to replace Crain.

Brakesol, Inc. of Oklahoma Ctiy has announced the appointment of **R. L. "Bob" Gibbins** to the position of special representative. He is stationed in Dallas. He was formerly in the sales department of Lone Star Steel for three years. Prior to that he was an independent oil operator in Oklahoma City.

Thomas E. Catlow has been appointed sales manager for the Odis C. Galloway Company, Beaumont, Texas. He will be in charge of sales and advertising.

Melvin A. Finuf, who has been assistant general manager of sales since August 1946, has been promoted to general manager of sales at The J. B. Beaird Company, Inc., Shreveport, Louisiana. He joined Beaird in 1935. **Gerald Pope,** who has been district sales manager of Beaird's Houston office, succeeds Finuf. **J. R. Sims,** who has been the compressor division sales engineer in Midland has been advanced to Houston replacing Pope.

M. A. Finuf

J. W. Gates

John W. Gates, sales manager for Well Equipment Manufacturing Corporation, Houston, Texas, has been elected vice president of Chiksan Company. He will continue in his present executive capacity with WECO. WECO is a division of Chiksan Company, which in turn is a subsidiary of Food Machinery and Chemical Corporation. He has been with the company 11 years.

Cameron Iron Works, Inc. of Houston has announced the promotion of **Allan D. Blackledge** from manager of the special products department to assistant manager of the company. **J. W. Brougher** was named the new manager of the special products department.

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MANX HOTEL
At Union Square
In the heart of the shopping, business, financial and entertainment districts. 300 guest rooms. Garage service. Cocktail Lounge.
Sightseeing and Travel Information in Lobby
300 Rooms
Singles from 5.50
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All with bath
225 Powell Street
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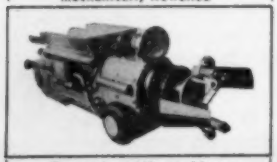
CALIFORNIA

Centrifugally applied and mechanically trowelled



Compact, mobile machine moves through the line

Centriline Process applies smooth, continuous leak-proof lining to inside of 16" to 144" pipe lines "in place." Applicable to fresh or salt water, oil, gas or industrial waste lines. Eliminates interior corrosion and leakage. Restores full flow coefficients.

Write for full information TODAY!

Specializing in Pipe Protection Problems • Tate and Centriline "In Place" Interior Cement Mortar Lining • "In Plant" and "Railhead" Centrifugal Spinning of Cement Mortar or Coal Tar Linings—Somastic® Exterior Coating • Pipe Wrapping • Reclamation: Removal of Old Wrapping, Straightening, Blasting, Beveling, Testing.

PIPE LININGS Inc.

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If you're healthy, you'll probably live longer because as it's said, "an ounce of prevention is worth a pound of cure." If you're nervous, tired, rundown or stiff from rheumatism and arthritis, you can find relief as thousands of others have. *You'll find the best at The Majestic* where you can go from your room to the bathhouse in robe and slippers. Here you will find specialists who know their business—experienced attendants and masseurs for the men and masseuses for the ladies—all licensed in accordance with the regulations under the Director of the Nat'l Park Service, U. S. Dep't of the Interior

THE Majestic HOT SPRINGS NATIONAL PARK ARKANSAS

HOTEL & BATHS

ROOMS *from—* $4 *per day single* $6*—double and you can budget* MEALS *at* $4.50 *per day*

Write the MAJESTIC today!

NEWS NOTES

CUMMINS SALES AND SERVICE, Inc., facilities in the Mid-Continent area have been extended further with the recent opening of a new shop and office at Biloxi, Mississippi. Facility is the fifteenth in the network of new complete Cummins Sales and Service, Inc., installations serving Texas, Oklahoma, Kansas, Louisiana, and Mississippi.

R. Carter Dye has been promoted to general sales manager for Olin Aluminum division of Olin Mathieson Chemical Corporation. He had been acting director of sales of the Aluminum division.

R. C. Dye

W. B. Denniston

William B. Denniston has been named sales manager of Panellit, Inc., Skokie, Illinois. He spent six years in sales management at the Shakeproof Division of Illinois Tool Works, Elgin, Illinois, and later in similar capacities at MacLean-Fogg Lock Nut Company of Chicago. During the past two years Denniston operated his own farm supply business near Elgin and Aurora, Illinois.

AN EXPORT SALES AND SERVICE agreement has been signed between the George E. Failing Company of Enid, Oklahoma, manufacturers of portable rotary rigs, and Distribuidora de Equipos de Construccion, S. A. de C. V., of Mexico City, Mexico. Juan Ortega will service the Failing account south of the border.

NATIONAL SALES COMPANY, A subsidiary of National Tank Company, Tulsa, Oklahoma, has been established in California, replacing American Pipe and Supply Company as a sales agency, according to Jay P. Walker, National president. Personnel of National Sales Company will be former employees of National Tank.

CAMERON IRON WORKS, INC. plans to construct a 30,000 sq ft plant, warehouse, and office building on U.S. Highway 90 between Morgan City and Franklin, Louisiana. This is the first of a series of moves to decentralize repair, assembly and distribution points.

APPOINTMENT OF WAUKESHA Sales and Service Company, Houston, Texas, as direct factory dealers for American MARC Diesel Engines has been announced. Waukesha Sales and Service will handle both the industrial and marine lines in a Southern six-states area.

EQUIPMENT ENGINEERS, INC. have assumed the manufacture and sale of certain oil production equipment formerly manufactured by the Drovil Company. Equipment covered by the agreement includes light oilfield production tools such as polish rod lubricators, stuffing boxes, tubing and casing swabs and sucker rod strippers.

MANUFACTURING FACILITIES and employees of Franks Division, Cabot Shops, Inc., will be moved from Tulsa to Pampa, Texas, in the near future. Operation of sales and service facilities will be continued in Tulsa. Move is being made to consolidate overhead and manufacturing costs with the Cabot plant which has modern material handling facilities, better arrangement, and is equipped with modern machine tools.

CLIMAX ENGINE MANUFACTURING Company, a division of Eversharp, Inc., has been announced as the new name of one of Climax Engine & Pump Manufacturing Company.

PRODUCTS ARE BEING REaligned. A new operating division of ACF Industries, Inc., called the Advanced Products Division, has been established as part of a major realignment of the company's products and plants. Manufacture of products for the petroleum, gas, chemical, and nuclear energy industries will be concentrated in the new division. Personnel and facilities of the ACF plants in St. Charles, Missouri, and Milton, Pennsylvania, will be assigned to the new division.

Promotion of **A. L. Dassler** from assistant chief engineer to chief engineer of Koehring Division, Milwaukee, has been announced. Dassler, who started with Koehring in 1953, will supervise design of the complete line of shovels, hoes, draglines and cranes. He will also be responsible for engineering developments on other Koehring Division products. **Kenneth Johnson,** senior designer, has been moved up to assume the post vacated by Dassler. Johnson joined the Koehring organization in 1949.

The Crest of Good Living in New York City

HOTEL New Yorker

34th Street at 8th Avenue

Manhattan's largest and most conveniently located hotel. 2500 outside rooms, all with bath and free radio, television in many. Direct tunnel connection to Pennsylvania Station. All transportation facilities at door. Three air-conditioned restaurants

LAMP POST CORNER . . . COFFEE HOUSE
GOLDEN THREAD CAFE

Singles from $7 | Doubles from $10 | Suites from $23

JOSEPH MASSAGLIA, JR., President
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World-famed hotels
Teletype service—Family Plan

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EASY TO READ MARKINGS THAT ARE DURABLE

DESIGNED FOR MAXIMUM ON-THE-JOB SERVICE

LUFKIN

CHROME CLAD "DERRICK" TAPE

Rugged service and dependable accuracy are carefully built into this fine tape. Narrow, sturdy line, with genuine Chrome Clad finish, is rust and corrosion resistant. Rollers in frame, oversize drum, and extra long handle provide extra leverage and quick, easy rewinding. Block hook with ribbed face quickly positions tape at zero for accurate measure. These are but a few of the Lufkin features that assure maximum on-the-job service.

BUY LUFKIN TAPES • RULES • PRECISION TOOLS FROM YOUR SUPPLY HOUSE

THE LUFKIN RULE COMPANY, Saginaw, Michigan
New York City Barrie, Ontario

BETTER MEASURE WITH LUFKIN

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

The stoutest pipe vise .... with built-in folding legs and tray

RIDGID

Tristand Pipe Vise

Extra easy to fold up, carry and set up... Extra strong, extra rigid in use

RIDGID Tristand Pipe Vise, yoke model.

Chain model also available.

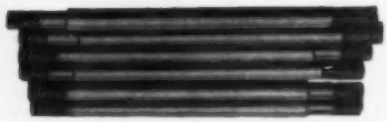
Most service and durability for your money! Integral legs and tray mean quick easy fold-up for carrying and set-up for work—provide solid stance, greater strength.

Vise base is roomy, has ceiling brace screw, pipe benders, slots for tools. Special LonGrip jaws grip tight without chewing up pipe. Save work—see it, try it, buy it at your Supply House.

The Ridge Tool Company, Elyria, Ohio, U.S.A.

RIDGID
Work-Saver Pipe Tools

Pump rods hard-faced by ThermoSpray Process give 20 times longer service



New Metco Process hard-faced acid sludge pump rods serve as much as 20 times longer than unfaced rods.

A number of oil companies are making important savings in equipment down-time and replacement part costs with the METCO THERMOSPRAY® Hard-Facing Process. Typical of these parts are pump sleeves, as well as the acid sludge pump piston and rods shown here. Operating conditions were severe—rods had to be replaced every 24 hours—new packing every 8 hours. Hard-faced rods now last over 500 hours; packing more than 60 hours. Coatings are extremely dense and non-porous—homogeneous.

The THERMOSPRAY Hard-Facing Process consists of spraying specially developed alloys in powder form with the METCO THERMOSPRAY GUN. No compressed air is required. Coatings have hardness of Rc 30 to Rc 65, depending on the specific THERMOSPRAY alloy used; will outwear hardened steels from 3 to 10 times. Spraying speeds are higher—8 to 10 lbs. per hour—and deposit efficiency far greater (up to 97%)—than with any other type of available equipment. Hard surface depth can be closely controlled and the smooth surface left after spraying requires a minimum of finishing.

Write today for free descriptive Bulletin 126A or a call by a full-time, company-trained, Metco Field Engineer in your territory. Or see your local metallizing job shop.

The following trade names are the property of Metallizing Engineering Co., Inc.: METCO®, ThermoSpray. ®Reg. U.S. Pat. Off.

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In Great Britain: Telephone: EDGEWOOD 4-1300
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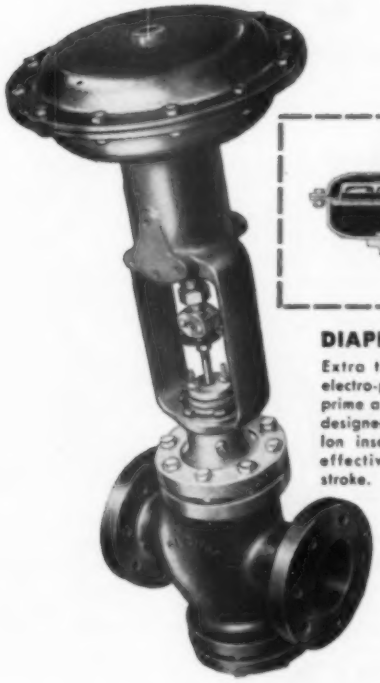
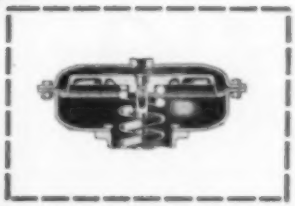
Any Way You Look At It

FISHER® Control Valves

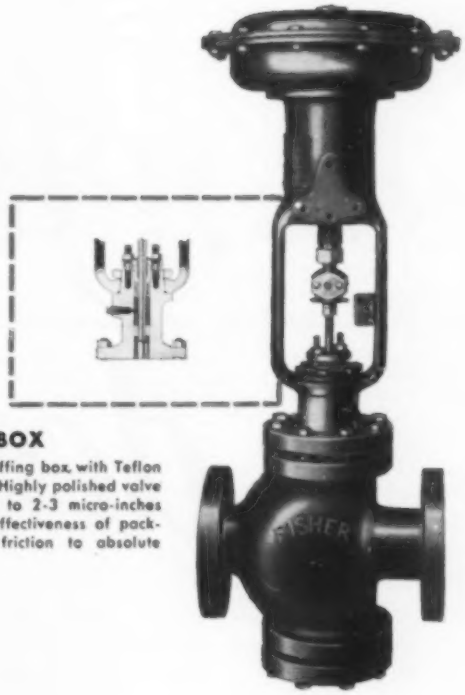
are your BEST BET!





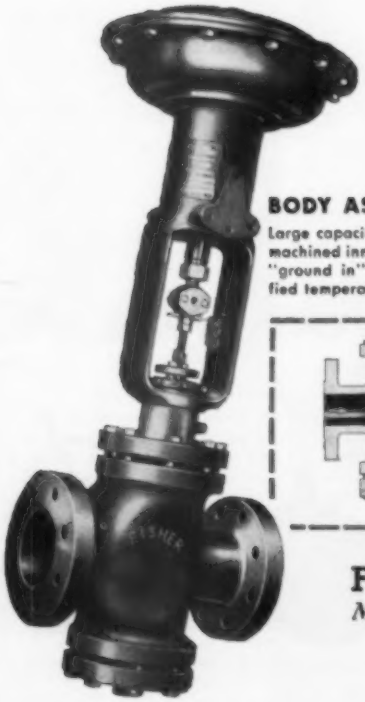
DIAPHRAGM ASSEMBLIES

Extra thick steel casings are zinc electro-plated, iridited and then given prime and final paint coats. Specially designed molded diaphragm with nylon insert gives practically constant effective area throughout valve stroke.



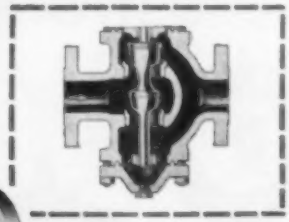
STUFFING BOX

Bolted gland stuffing box with Teflon V-Ring packing. Highly polished valve stem is finished to 2-3 micro-inches RMS to insure effectiveness of packing and keep friction to absolute minimum.



BODY ASSEMBLIES

Large capacity bodies with accurately machined inner valves are individually "ground in" under customer's specified temperature conditions.



Realizing their importance in the control system, Fisher has given careful attention to design and construction of diaphragm control valves. Any way you look at it — from the standpoint of durable construction or accuracy of performance—Fisher Diaphragm Control Valves are your best bet.

FISHER GOVERNOR COMPANY

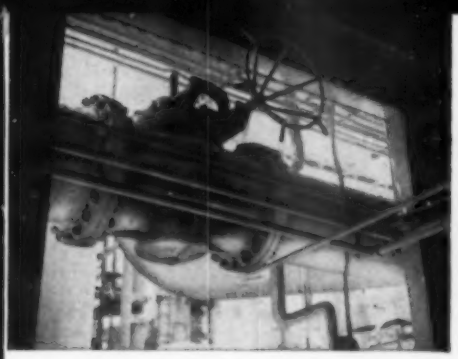
Marshalltown, Iowa • *Woodstock, Ontario*

World Leader in Research for Better Pressure and Liquid Level Control

where to save refining dollars

WITH

ROCKWELL-Nordstrom **VALVES**



CATALYTIC CRACKING

From the smallest valves to the large emergency flow line valve above, Rockwell-Nordstrom valves keep process units on stream without costly down time. Lubricant stops valve trouble *before* it has a chance to start.

CATALYTIC POLYMERIZATION

The Rockwell-Nordstrom valve shown above on the reactor feed line insures trouble-free flow control. Since the plug is fully opened or closed with just a quarter-turn, gear operation is two to five times faster than ordinary valves.

GAS SERVICE

On intake or discharge gas lines, Rockwell-Nordstrom valves—20" valve shown above—operate easily and won't stick. The perfectly seated plug is "cushioned" on pressurized lubricant for instant, easy operation.

GAS SYNTHESES

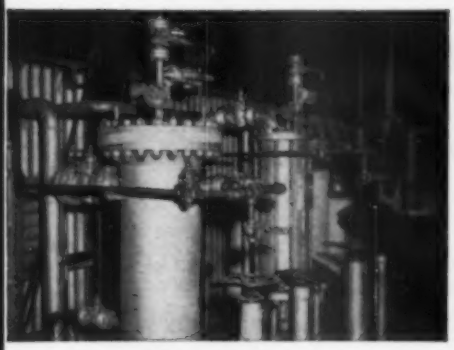
Where leakage is not only troublesome, but hazardous, you'll often see Rockwell-Nordstrom Hypreseal valves like the ones shown above. Pressurized lubricant in the sealing grooves acts like a *permanent soft seat* that is instantly replaceable.

PROCESS LINES

On cat cracker process lines Rockwell-Nordstrom valves stay trouble-free month after month. Lubrication of valves on services like this is positive protection against costly valve failures. And Rockwell-Nordstrom valves can be quickly and easily lubricated or adjusted without down-time.

SULPHUR RECOVERY

Tough services like sulphur production are easy for Rockwell-Nordstrom lubricated plug valves. Seating areas are *never* exposed to the line and the tough film of lubricant insures a bottle-tight seal on services where other valves fail quickly.



AMMONIA

The little (1") Rockwell-Nordstrom valves on the Ethylene and Methene service above do a big job of trouble-free, leakproof flow control. In any size, Rockwell-Nordstrom valves take less space and can be manifolded far tighter than ordinary valves.

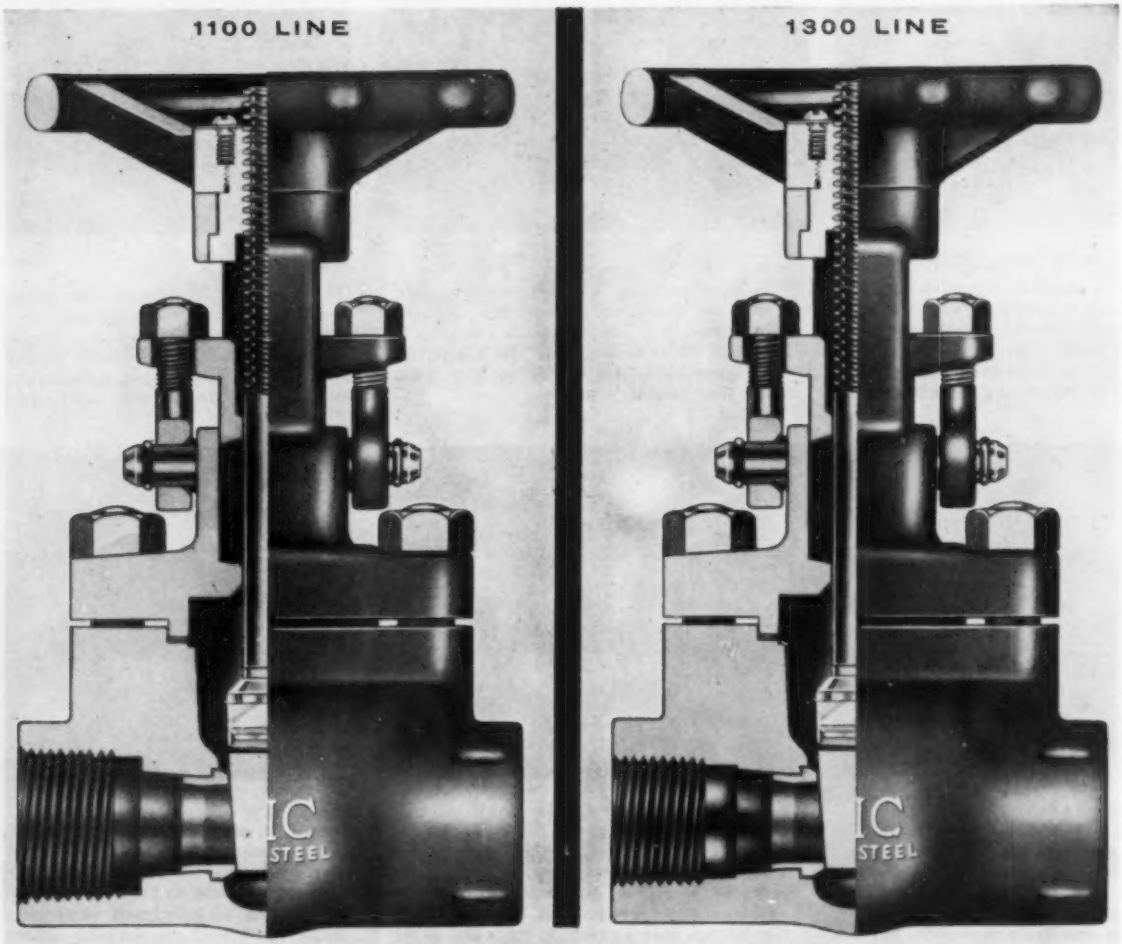
STORAGE AND TRANSFER

Rockwell-Nordstrom valves will prove profitable throughout the transfer and storage system. Select from a *complete* line of valves and from a wide variety of operating accessories to answer your every flow control need. Positive shut-off stops product contamination and leakage hazards.

Refinery maintenance records all over the country prove that you can't make a better valve investment than Rockwell-Nordstrom. No matter what your valve requirements, there is a Rockwell-Nordstrom lubricated plug valve that will do the job better and at far lower cost. And they cost no more to buy, often less, than ordinary valves. Write today for complete details. Rockwell Manufacturing Company, Pittsburgh 8, Pa. Canadian Valve Licensee: Peacock Brothers Limited.

ROCKWELL-Nordstrom VALVES

Lubricant Sealed For Positive Shut-off



New, OIC bolted bonnet, 600 lb. forged steel gate valve lines, ½" to 2" with HCH, all purpose trim.

2 new rugged OIC forged steel lines

Both feature the modern and rugged bolted bonnet joint, which simplifies and lowers the cost of maintenance.

Both feature a soft iron gasket securely retained in the bolted male and female body-bonnet connection to assure enduring tightness.

Both feature 13% chrome stainless steel trim with 1000 Brinell, duracased wedges.

Both feature plenty of gripping area for pipe wrenches on pipe ends; there's no interference with body-bonnet flanges. Simplifies joint make-up!

The 1300 line includes a *high flow* port area, offering full-flow characteristics.

The 1100 line, with standard flow ports, is compact, economical, and includes the same high quality, rugged features and trim as the 1300 line.

Most valve users have applications suited to both of these new OIC valve lines. Write for Bulletin *#195-R* illustrating features and specifications that fit these newest forged steel valves to your services.

THE OHIO INJECTOR COMPANY • WADSWORTH, OHIO

VALVES | FORGED & CAST STEEL, LUBRICATED PLUG, BRONZE & IRON VALVES

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

NEW!

TUBE-TURN* "TAPER FACE" FLANGE

...cuts cost of light-duty piping

...protects low pressure pumps and valves

Tube Turns announces a new lightweight welding neck flange for service up to 125 lbs. W.O.G. pressure, offering two important cost-cutting advantages: (1) It is priced lower than conventional flanges. (2) This lightweight welding neck flange has a tapered face which affords an effective seal with reduced bolt loading; hence, permits use of steel butt welding neck flanges without danger of cracking the flat faced cast iron flanges of valves and pumps used in low pressure piping systems. Here is another result of Tube Turns pioneering research, and an example of how you get *more for your money* when you specify TUBE-TURN Welding Fittings and Flanges and buy them from your nearby Tube Turns' Distributor.

tt
TUBE-TURN

*"TUBE-TURN" and "tt" Reg. U. S. Pat. Off.

The Leading Manufacturer of Welding Fittings and Flanges

TUBE TURNS LOUISVILLE 1, KENTUCKY

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HOW TO SAVE

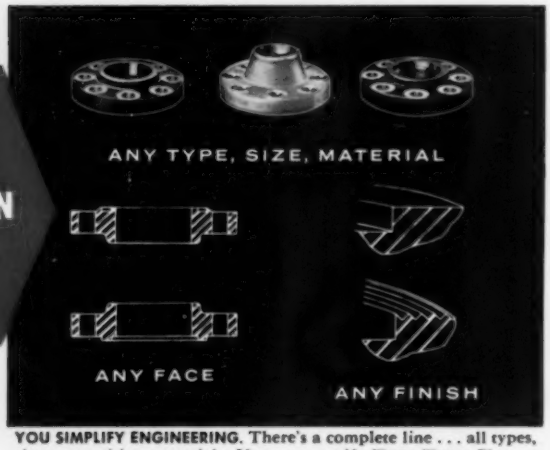
How you cut costs with
TUBE-TURN FLANGES

with the **NEW** Taper Face Flanges

CUTS FLANGE COSTS. For many applications of light-duty piping . . . up to 125 lb. W.O.G. pressure . . . the new TUBE-TURN Taper Face Flange gives rated performance at a lower price than conventional designs. Here's a good teammate for lightweight pipe and fittings in applications such as water, oil and gas distribution . . . on pumps and compressors . . . any installation where welded piping must be flanged to low pressure valves, pumps or equipment.

PROTECTS VALVES AND PUMPS. Lightweight and tapered face permit good seals with reduced bolt-loading on valve or pump flanges. Lighter, lower-priced valves can be used without danger of cracking their flat faced cast iron flanges. Also, lighter neck of flange speeds up welding to pipe.

with all **TUBE-TURN** Flanges



YOU SIMPLIFY ENGINEERING. There's a complete line . . . all types, sizes, capacities, materials. You can specify TUBE-TURN Flanges and know you'll get the exact answer to your problem. Also, Tube Turns offers you engineering help.

YOU STREAMLINE PURCHASING. Your nearby Tube Turns' Distributor provides complete-line service. This one source for all your needs in welding fittings and flanges enables you to put *all* your requirements on *one* order . . . to cut red tape, save valuable time.

MAIL FOR BOOKLET The New line of Taper Face Flanges is described in this Tube Turns booklet . . . free on request.

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224 East Broadway, Louisville 1, Kentucky
Please send free Bulletin on Taper Face Flanges.

Company Name _____

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Available from your nearby TUBE TURNS' distributor

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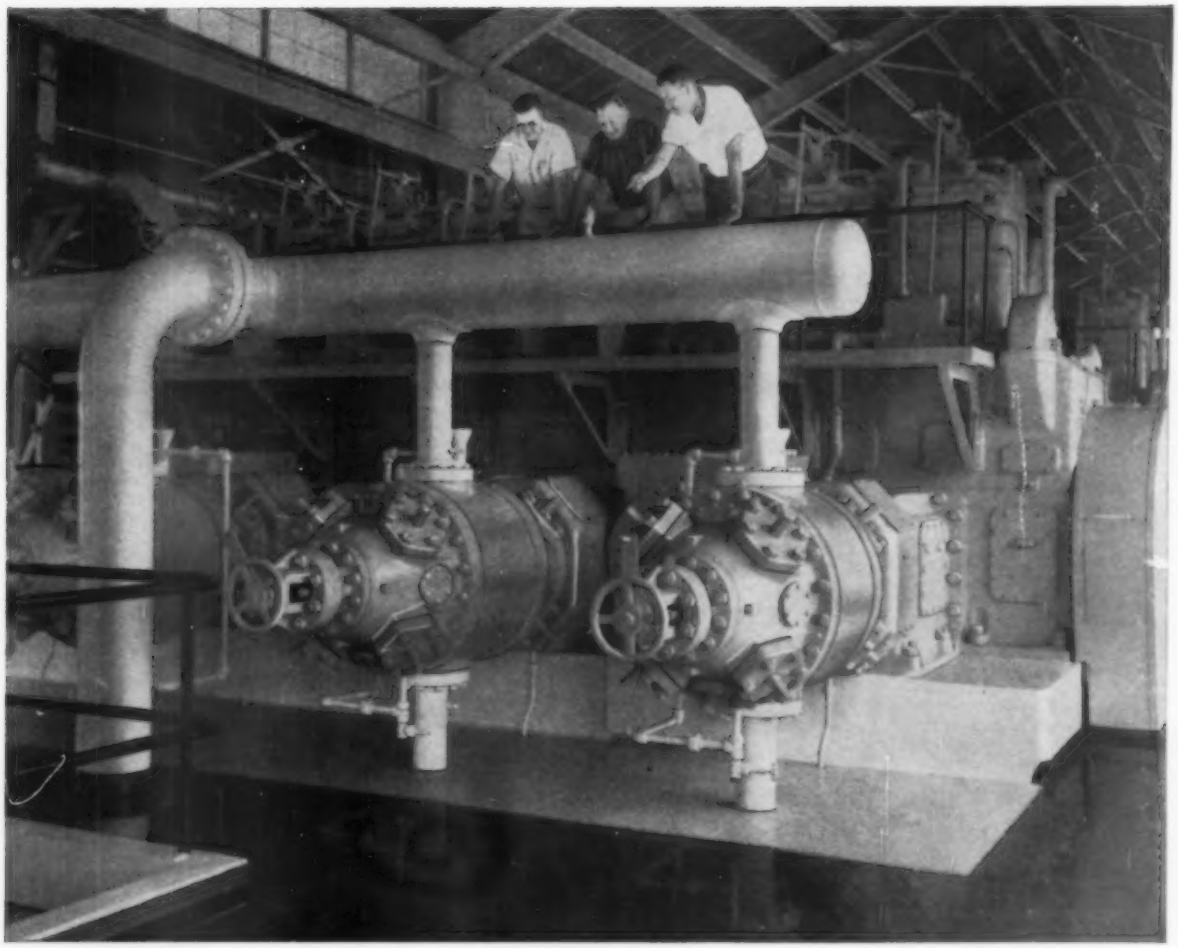

Richard N. Rogers, Results Engineer (left), W. C. Drienhofer, Station Superintendent, and R. A. Cuyler, Jr., Gulf Sales Engineer, inspect one of the 31 units lubricated by Gulf Security since 1944.

At Tennessee Gas Transmission Company's Middleton Station . . .

Not a ring change in 26,800 hours with

GULF SECURITY OIL

31 gas engine compressor units have been running smoothly at the Middleton Station with Gulf Security Oil since 1944. The records show 26,800 hours operation without a single ring change. And after 85,000 hours, Security in the crankcase was still in excellent condition.

Here for 13 years Gulf Security has lived up to its name—security against operating troubles and high maintenance costs. Gas engine compressor units lubricated with Gulf Security are consistently free of heavy port and ring belt deposits. Wear is negligible—in fact, ring and liner life in both power and compressor cylinders is well above average. Bearings last longer, too.

When you use a Gulf product you get an extra dividend—the free services of an experienced Gulf engineer. He's always "on call" to assist you with any problem involving lubricants, fuels, or any other petroleum product. Write, wire or phone your nearest Gulf office.

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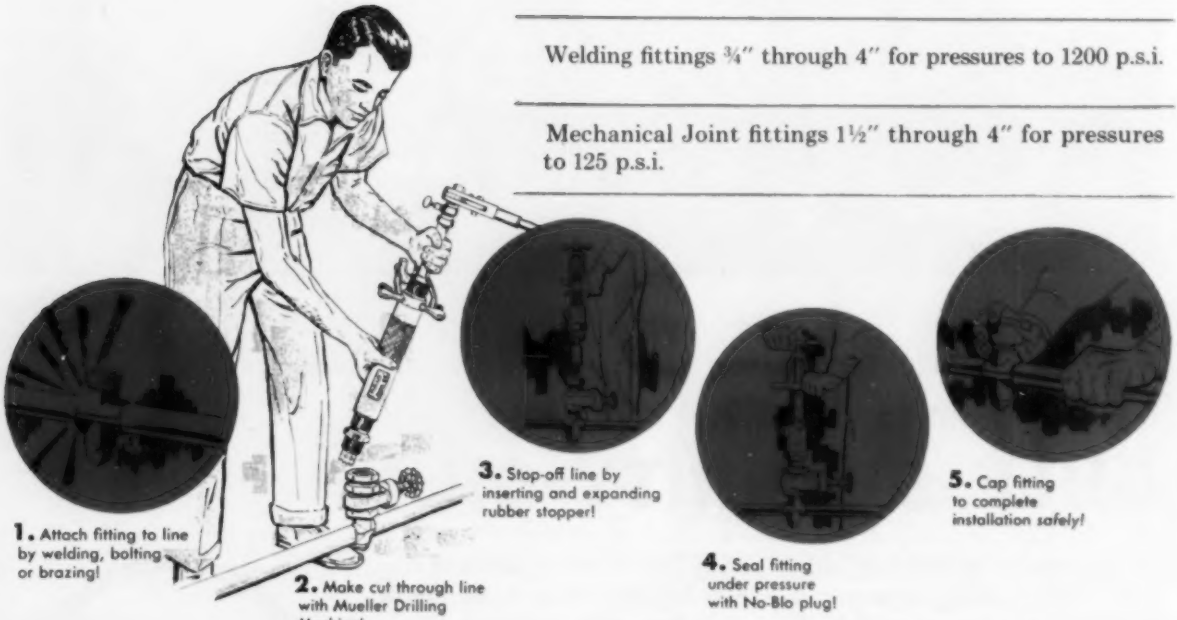

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2. Make cut through line with Mueller Drilling Machine!

3. Stop-off line by inserting and expanding rubber stopper!

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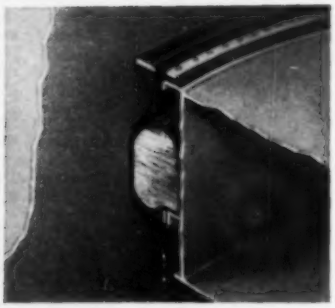

TUBESEALS are made lightning-proof with their exclusive electric conductor weather seal.[1] This specially compounded synthetic rubber, extending continuously around the entire perimeter, between roof and tank shell, provides an infinite number of contact points. ELABORATE TESTING by an independent laboratory[2] discloses that the seal prevents isolation and collection of static electricity charges, providing a continuous conductive surface with large current carrying capacity. Induced charges from lightning are immediately dissipated and fires are prevented. There are no mechanical contacts to cause sparking.

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Introduced to the oil industry late in 1955, the Hammond Tubeseal found immediate favor with oil companies all over the world . . . there are now more than 200 installations in operation and building. A measure of their conservation values and fireproof features is illustrated by their record of repeat orders from satisfied users—one large oil company, after several test installations, re-ordered more than a score of Tubeseals. The same story of satisfaction exists wherever a Tubeseal is in operation.

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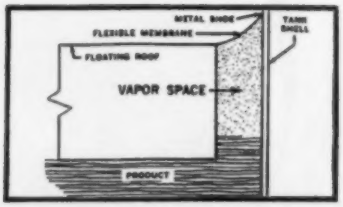
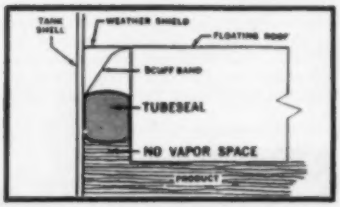


CONVENTIONAL FLOATING ROOF tank has space below flexible membrane where air-vapor mixtures form. Because metal shoe and membrane cannot be absolutely gas tight, vapor is constantly escaping. This condition causes excessive corrosion, may also result in rim fires from lightning or other source.



HAMMOND TUBESEAL FLOATING ROOF entirely eliminates every space where air-vapor mixtures can form. Hammond Tubeseal completely fills space between product surface and roof seal, so that corrosion is stopped (even for sour crudes), and vapor cannot form—hence cannot ignite or be lost.

THE HAMMOND TUBESEAL
for new or old floating roof tanks,

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- **non-corrodible**
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- **no vapor space below the seal**
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*Patented [1]patent pending [2]names on request

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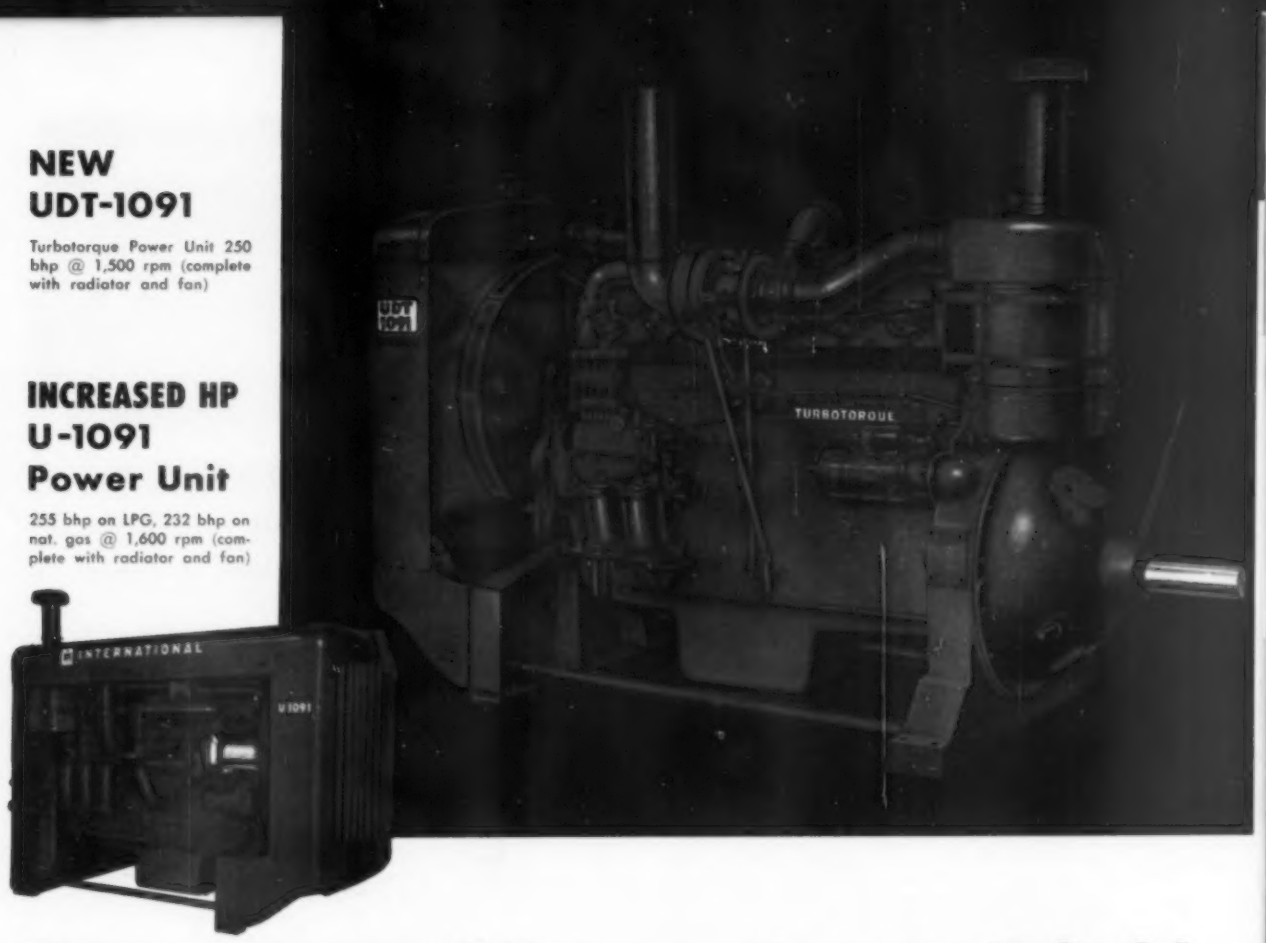
INCREASED HP U-1091 Power Unit

255 bhp on LPG, 232 bhp on nat. gas @ 1,600 rpm (complete with radiator and fan)



Power range of International oil field engines increased to 269 usable hp.

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POWER RATING

Model	Cyl.	Fuel	Intermittent Load Bph
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UDT-1091	6	Diesel	265 @ 1,500 rpm
UD-1091	6	Diesel	214 @ 1,500 rpm
U-1091	6	LPG	269 @ 1,600 rpm
		Nat. Gas	247 @ 1,600 rpm
Complete Power Unit With Radiator and Fan			
UDT-1091	6	Diesel	250 @ 1,500 rpm
UD-1091	6	Diesel	200 @ 1,500 rpm
U-1091	6	LPG	255 @ 1,600 rpm
		Nat. Gas	232 @ 1,600 rpm

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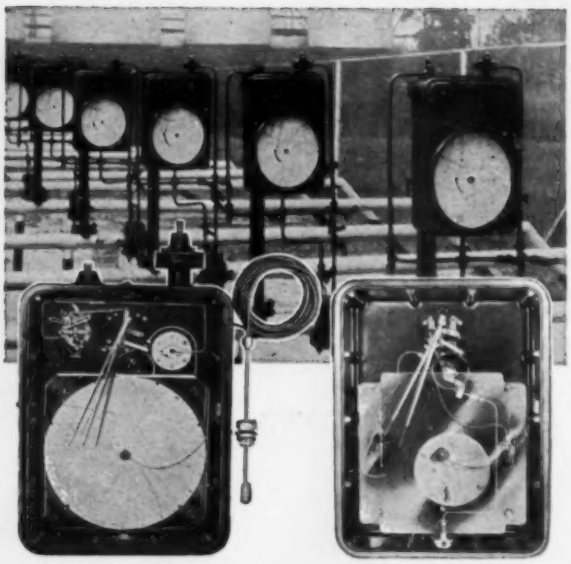

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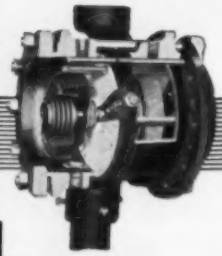

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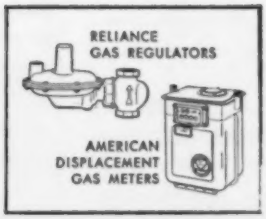

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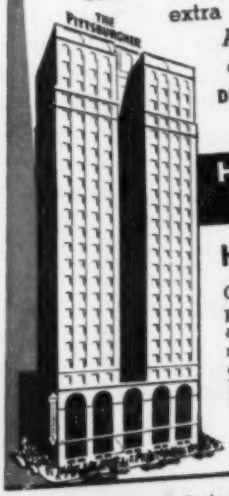

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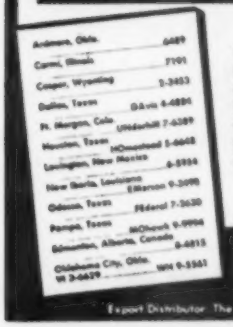
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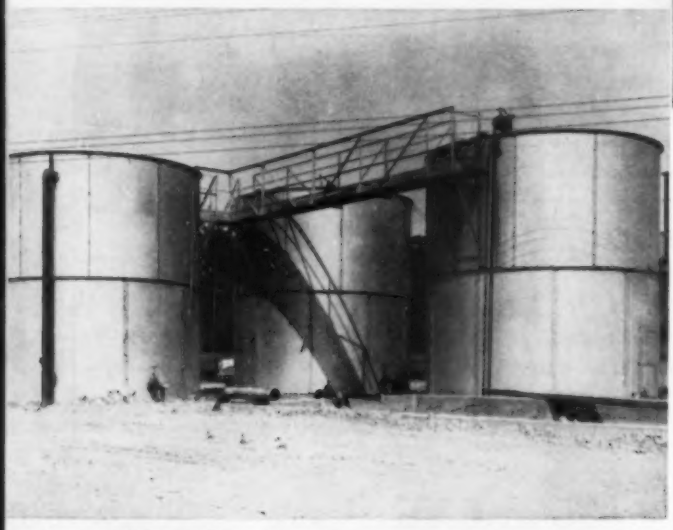

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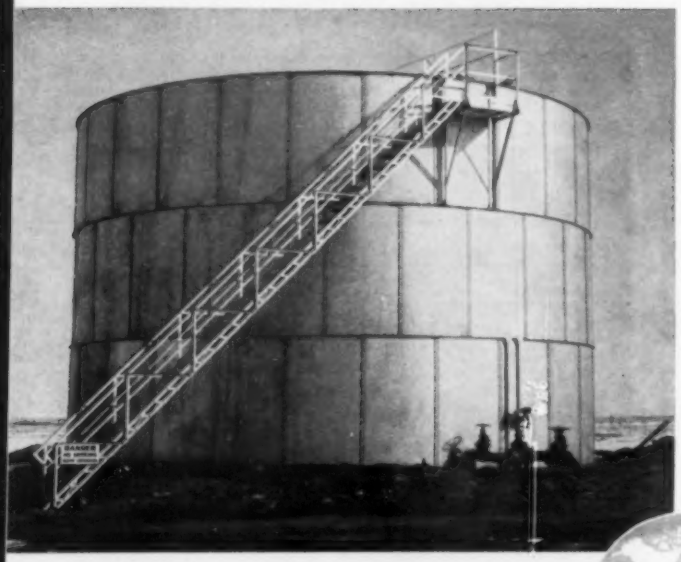

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100	500	3,000
130	750	3,333
195	1,000	5,000
200	1,500	6,666
250	All made to API Dimensions	10,000

*Delivered immediately means the time necessary to haul to location from any one of 45 correctly located Bolted Steel Tank stocks in the U.S. and Canada. National Supply Corp., our export agents, carry our tanks and parts in several foreign countries, including Venezuela.

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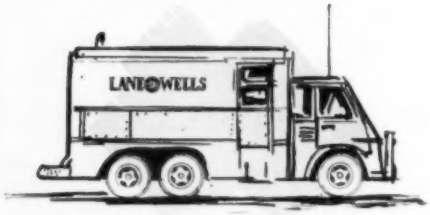
Yes, when you use Lane-Wells perforating service you can get maximum penetration in both bullet and shaped-charge perforating...

...BECAUSE



Because Lane-Wells 4 inch E-Gun blasts deeper than any 4 inch bullet gun available on the market today—25% deeper than its closest competitor.*

...BECAUSE

Because Lane-Wells 4 inch Karrotfree Koneshot ® blasts deeper than any 4 inch shaped-charge gun available on the market today—shoots 12.3% deeper than its closest competitor.*

* From the published results of independently conducted tests.

Your LANE WELLS man has the full story ...ask him to give you the facts

LANE-WELLS COMPANY

FOR INFORMATION WRITE:
P. O. BOX 1664, HOUSTON 1, TEXAS

LANE-WELLS CANADIAN CO. IN CANADA
PETRO-TECH SERVICE C.A. IN VENEZUELA

Of Things To Come . . . In Oil

NO OFFSHORE BOUNDARY SETTLEMENT can be expected before next fall — at the earliest. The Supreme Court, before closing shop for the summer, ruled that states other than Louisiana, whose tidelands ownership is under question, should be heard in the case. Other states include Texas (who had asked to be heard), Mississippi, Alabama, and Florida.

THE *BIG* HURRICANE YEAR? Some meterologists think this may be it. Audrey, first major Gulf disturbance, certainly gave the 20 expected hurricanes of the 1957 season something to shoot at. Hundreds of persons lost their lives and total damage is yet uncounted in one of the most serious initial seasonal hurricanes recorded.

AN END TO PIPELINE PRORATION is in sight for producers in parts of Oklahoma and other southwestern states. Texas Eastern Transmission's gas-to-products conversion of the Little Big Inch line will permit eventual movement of 250,000 bbl daily eastward from overstocked Mid-Continent refineries, permitting large crude takes from purchasers and producers. Line conversion will be complete in September with an initial take of 185,000 bbl daily.

WYOMING DRILLING AND PRODUCTION IS UP over anticipated 1957 levels, as hopes mount for new Mesaverde production in the vast Powder River Basin. Three majors and several independents are now probing the area's strat traps to put structure correlation on a firm basis. University of Wyoming's Dr. Horace D. Thomas recently pointed out several new fields "characteristically different from conventional oil fields," enhancing "possibilities of many more fields in the state."

HIGHER PRICED OILFIELD EQUIPMENT and oil country tubular goods are the expected reverberations of June $6 per ton steel price increase. Steel mill hike announcements immediately sent tubular goods prices up $8 to $10 per ton. Other price ripplings have followed the increase into price consideration of nearly all basic "hard" commodities. Don't look for crude prices to follow the new pattern any time soon, however.

Wells completed weeks sooner— by using low-solids drilling fluid

Drilling Milk
A SPECIAL EMULSIFIER FOR CLEAR WATER DRILLING AND LOW SOLIDS FLUIDS
MAGNET COVE BARIUM CORP.
HOUSTON, TEXAS

Contractors can knock weeks off drilling time . . . and get wells on production sooner . . . by using low-solids oil emulsion fluid. Made with Aquaness emulsifiers, the original high-speed drilling fluid emulsifiers, this fluid is making possible lower drilling bids, with fair profit to contractors. It has been used with outstanding results in over 500 wells.

PENETRATION RATES INCREASED. Tests on offset wells show low-solids fluid boosts penetration rates from 26 to 41%.

TRUER GAUGE HOLE DRILLED . . . less cement required.

MUD CONTROL SIMPLIFIED. Solids drop out quickly. No foaming. Minimum mud service. Mud flows like water; viscosity can be easily controlled. Faster mud conditioning.

LOST CIRCULATION REDUCED. Weights are lighter; pressures are lower.

LARGER CUTTINGS. Better for geological analysis.

SALT AND AIR CORROSION RETARDED by excellent inhibiting properties of this fluid.

ASK YOUR MAGCOBAR DEALER ABOUT DRILLING MILK*

. . . or write to Magcobar about this emulsifier for low-solids fluids.

*Trademark Magnet Cove Barium Corporation.

LOOK FOR THE AQUANESS SEAL

It identifies the **original** *low-solids, high-speed drilling fluid emulsifier, made by Aquaness for leading mud companies.*

ATLAS

Aquaness *Department*

ATLAS POWDER COMPANY

2005 Quitman Street, Houston 26, Texas

"Best tractor I've ever used— a 'lifesaver' in emergencies"

. . . says
Oklahoma contractor

Here Basinger's HD-6 backfills a slush pit. This tractor digs and fills about 100 pits a year. It also builds roads and creek crossings, digs ditches, levels well sites, clears timber, moves heavy machines and tanks.

"In fourteen years of oil field dirt moving, I haven't used anything that matches my new Allis-Chalmers HD-6 tractor-dozer. It moves more dirt, clears timber and builds roads faster, and it's a real 'lifesaver' in emergencies," says A. E. Basinger, Bartlesville, Oklahoma, oil field contractor.

"If a well busts out we've got to dig a new slush pit to catch the oil or salt right away — no matter what the time or weather. That's when this HD-6's big output really pays off. Another thing, with that direct electric starter, it's ready to go in seconds."

Says veteran operator L. B. Tevebaugh, "This tractor's the best I've ever operated. It starts fast, handles easy, won't kick back in the rough spots. Seat's comfortable, brakes are good. It's so well balanced I can operate in places I couldn't work a tractor before. On hillside diggin' for a rig site, the tilt blade helps me level up in half the time.

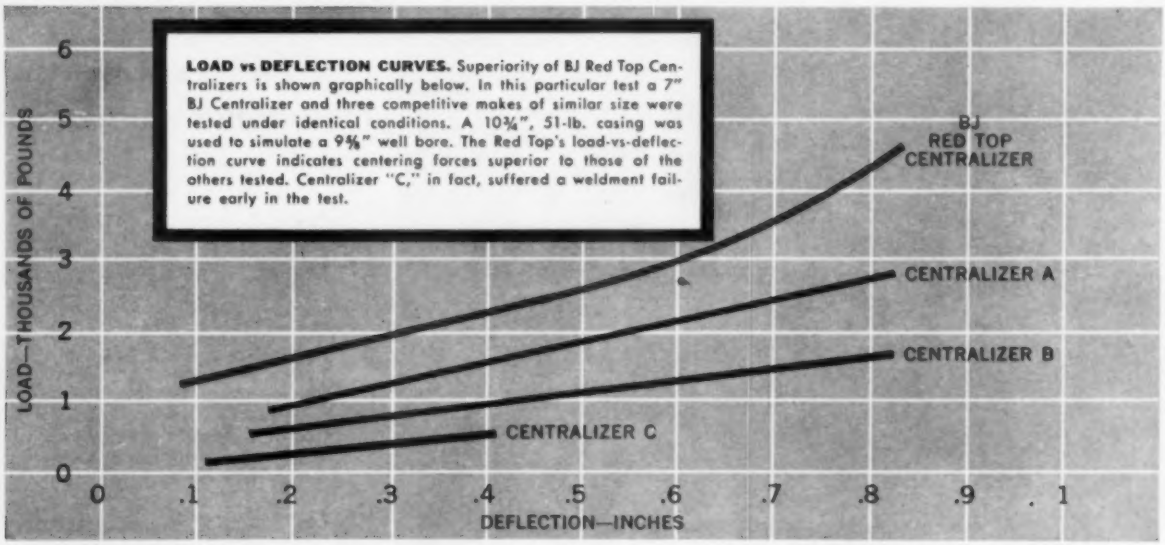
"Another thing with the Allis-Chalmers setup, I don't waste a lot of time greasing idlers and sprockets. I sure wouldn't want to go back to the old way."

Find out how Allis-Chalmers crawlers can pay off on your leases. Your nearby dealer can give you the facts.

ALLIS-CHALMERS, CONSTRUCTION MACHINERY DIVISION, MILWAUKEE 1, WISCONSIN

ALLIS-CHALMERS *Engineering in Action*

BJ Centralizers


LOAD vs DEFLECTION CURVES. Superiority of BJ Red Top Centralizers is shown graphically below. In this particular test a 7" BJ Centralizer and three competitive makes of similar size were tested under identical conditions. A 10¾", 51-lb. casing was used to simulate a 9⅝" well bore. The Red Top's load-vs-deflection curve indicates centering forces superior to those of the others tested. Centralizer "C," in fact, suffered a weldment failure early in the test.
LOAD—THOUSANDS OF POUNDS
0
1
2
3
4
5
6
0
.1
.2
.3
.4
.5
.6
.7
.8
.9
1
DEFLECTION—INCHES
BJ RED TOP CENTRALIZER
CENTRALIZER A
CENTRALIZER B
CENTRALIZER C

Test results confirmed by an independent testing laboratory

Now for the first time there is tangible evidence of centralizer performance. A series of rigorous tests have been made upon stock samples of representative makes of casing centralizers used in the oil fields throughout the world. These centralizers were put through stresses that simulated the most grueling down-hole conditions. And in every case, BJ Red Top Centralizers outperformed all the competitive models tested.

These outstanding findings were far from accidental. With typical thoroughness, the Byron Jackson Division of Borg-Warner Corporation had subjected the BJ Red Top Centralizers to a battery of tests that were even more stringent than the subsequent independent project. The centralizers underwent several years of exhaustive study, design, tests, redesign, and more tests before they were offered to the petroleum industry.

Meticulous single-spring tests were made by BJ technicians to develop the best individual spring characteristics as well as the optimum resiliency of the assembled units. These tests were possible only because of BJ's exclusive *weldless, rivetless design*, which permits use of a higher quality alloy spring steel.

Only BJ Centralizers have the combination of features that guarantee you an efficient, trouble-free cementing program and maximum protection for your down-hole dollar. Get full particulars from your BJ field man or write Byron Jackson Tools, Inc.

best by test!

These points put BJ Centralizers on top in rugged competition

No load on casing! Springs fulcrum on cage. Casing always rotates freely.

Pre-stressed springs give higher initial load—assure maximum centering force with minimum set.

Rivetless, weldless construction makes possible the use of highest quality alloy spring steel...

Slim design allows easy insertion into the hole.

Hinged design offers quick, simple clamp-on.

End cages can't hit well bore, regardless of side load.

Choice of 1¼", 1⅛", 1¾" or 2" (color-coded) cambers.

Cambers dimensioned before pre-stressing and assembly. You always get the required assembled o.d.

Positive double retaining feature locks pin with dimple in middle and bend at end.

End of spring is curved so spring-holder can never hit wall.

Self-aligning, weld-on type stop collar furnished for use when centralizer is not located on casing collar.

Big Savings

BJ Red Top Centralizers can be shipped disassembled, offering big savings on shipment costs—particularly for export. Assembly tool available.

Watch for New Companion Tools

WATCH BJ FOR THE NEWEST

Byron Jackson Tools, Inc.

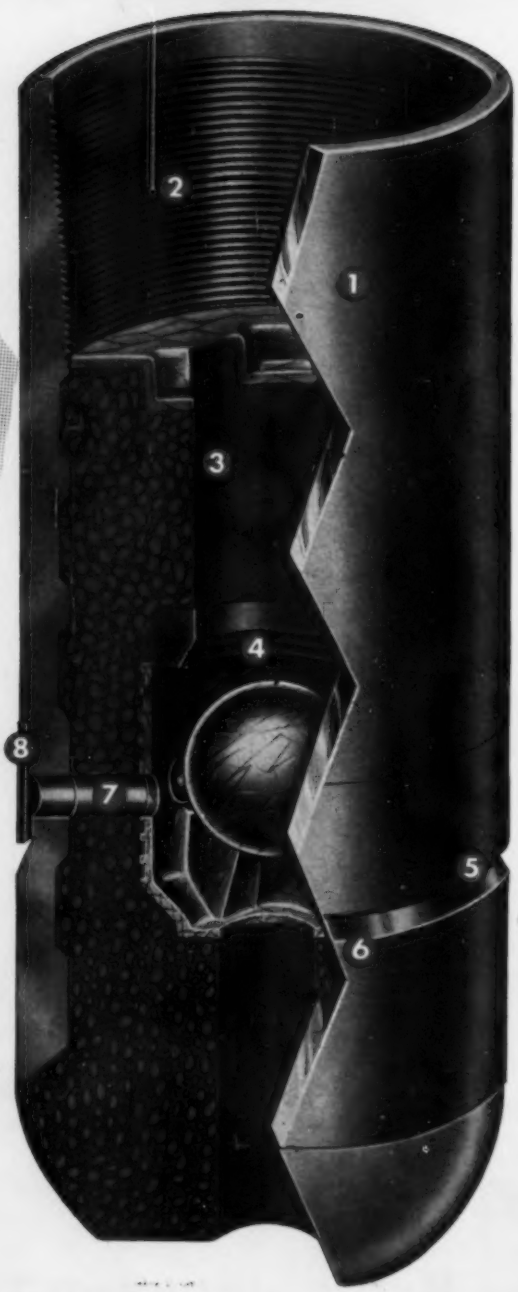
A subsidiary of Borg-Warner Corporation

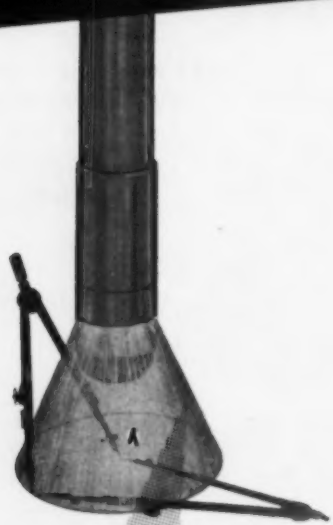
P.O. Box 2017A, Terminal Annex · Los Angeles 54, California

Every Advantage for Successful Cementing

LARKIN GEYSER SHOE

1. Made of tough seamless forging.
2. Furnished with any thread desired.
3. High strength, scientifically cured red granite concrete.
4. Superior all-Bakelite back pressure valve. The strong, efficient back pressure valve assembly is composed of a precision-ground Fabric Base Bakelite Ball which seals against a firmly reinforced Hycar seat. Valve seals immediately against high or low pressures and is stronger than the collapse strength of the casing.
5. Geyser action discharges slurry around the entire periphery of the shoe to assure an even distribution of cement and to minimize channeling.
6. Geyser action up or down.
7. Eight large discharge ports provide unrestricted flow into the peripheral discharge area.
8. Single baffle plate provides powerful 360 degree jetting action.





The Larkin-Field-Proved Shoe design has won in field after field the reputation of doing all that a cementing shoe can do to contribute to a successful cementing job. Specify Larkin Geyser Shoes and Collars on your next cementing job. They are sold ". . . through your Supply Store."

LARKIN PACKER COMPANY, INC.
WAXAHACHIE, TEXAS

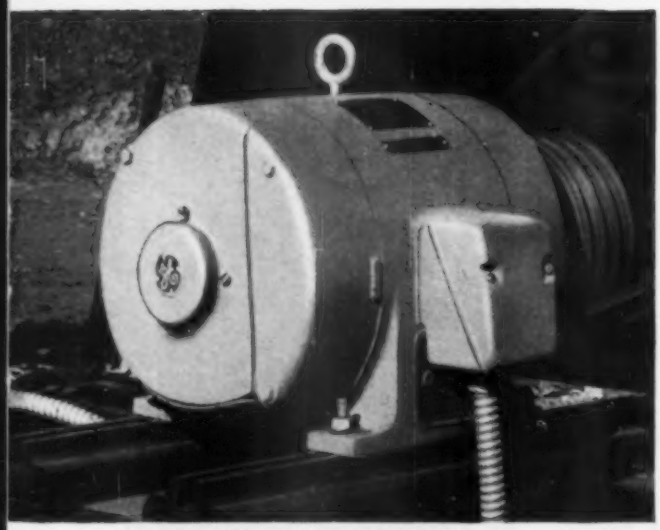
LARKIN
...Through Your Supply Store

LARKIN LEADERSHIP HAS BEEN EARNED BY YEARS OF DEPENDABLE PERFORMANCE

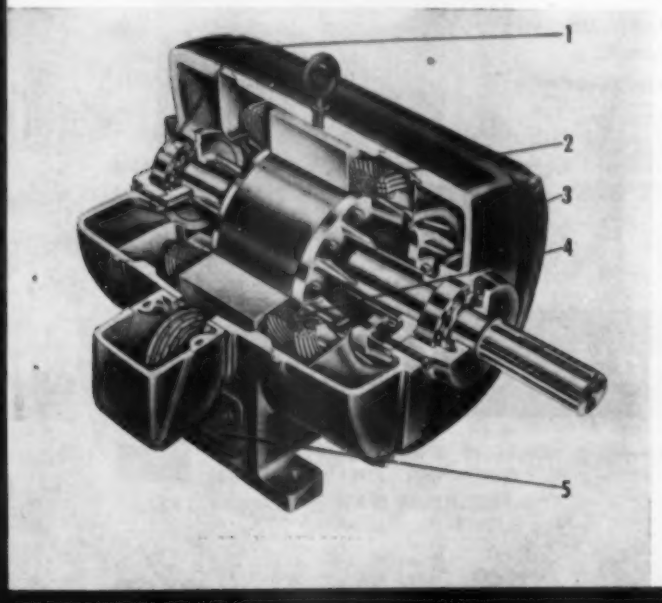
INSTALL IT... FORGET IT!

EASY-TO-MAINTAIN G-E TRI 55 CLAD MOTORS LAST LONGER

REG. U.S. PAT. OFF.



GREATER RIGIDITY AND STRENGTH of cast-iron frame and end shields prevent motor from being twisted out of line. Integrally cast ribbing on underside adds extra support.



General Electric's all-new Tri-Clad '55' oil field motor is specifically designed for long-life, easy-maintenance operation on your pumping applications. Protected against burnouts, dust and moisture, the new motor will run far longer without attention than ordinary motors.

Burnout protection for longer life—Burnouts are virtually eliminated with new Class 'B' insulation system utilizing Alkenex® heat-resistant wire enamel, and mica-glass laminate slot and phase insulation. This new system allows up to 40% higher temperature rise, yet extends motor life.

Advanced bearing system for easier maintenance—Under normal operating conditions, the advanced bearing system will operate longer without regreasing than any other motor bearing system. Effective seals on both sides of bearing housing keep grease in and dirt out, giving you all the service the long-lasting lubricant can deliver. Large grease reservoir *reduces maintenance to a few minutes every 5 years*. Pipe plugs on bearing housing permit regreasing even when motor is operating.

Greater physical protection for outdoor service—The new Tri-Clad '55' motor is built to take the weather. End shields and frame are rust-resistant cast iron. The insulation system virtually eliminates breakdown due to moisture. Air vents are protected, and removable screens guard against animal and rock damage.

Complete information available locally—For full details on the easy-to-maintain, long-life Tri-Clad '55' oil field motor, contact your local G-E motor distributor or your nearby General Electric Apparatus Sales Office. General Electric Company, Schenectady 5, N. Y. 899-1

CHECK THESE YEARS-AHEAD FEATURES

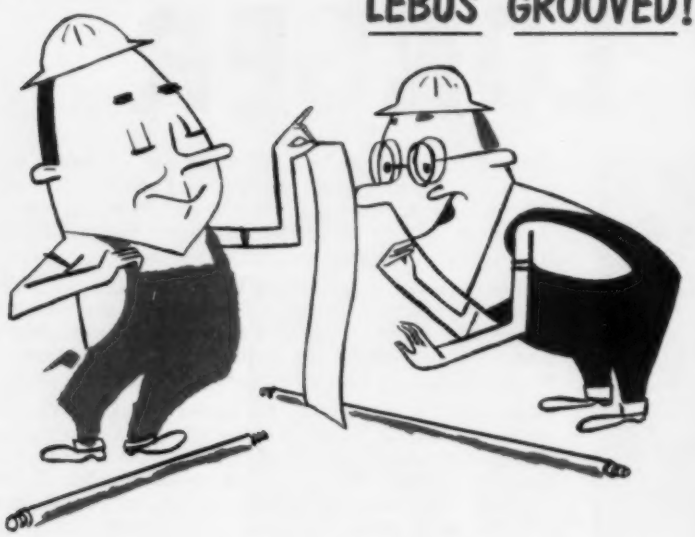
1. Advanced bearing system will last longer without regreasing than any other bearing system.
2. Water-shedding stator windings virtually eliminate breakdown due to moisture.
3. Rugged cast-iron frame helps prevent rust and accidental damage.
4. Class 'B' insulation system with revolutionary Alkenex® wire enamel allows up to 40% higher temperature rise . . . yet extends motor life.
5. Removable screens protect G-E oil field motors against damage from rodents and rocks.

Progress Is Our Most Important Product

GENERAL ELECTRIC

Look at that log and the drilling time we've saved-

Since that hoist was LEBUS GROOVED!*



Like the saying . . . *When in Rome, do as the Romans do* . . . we feel we can apply the same to spooling wire line. So we say . . . When Spooling Wire Line, do as the successful operators are doing . . . install the LEBUS COUNTERBALANCE GROOVING AND WIRE LINE SPOOLING SYSTEM. LeBus Engineers, with an extensive record of grooving more than 2500 active drilling rigs can prove why LeBus Spooling* is Perfect Spooling. Let them show you how to SAVE drilling time and wire line, while increasing the efficiency of your rig operation through correct LeBus Spooling.*

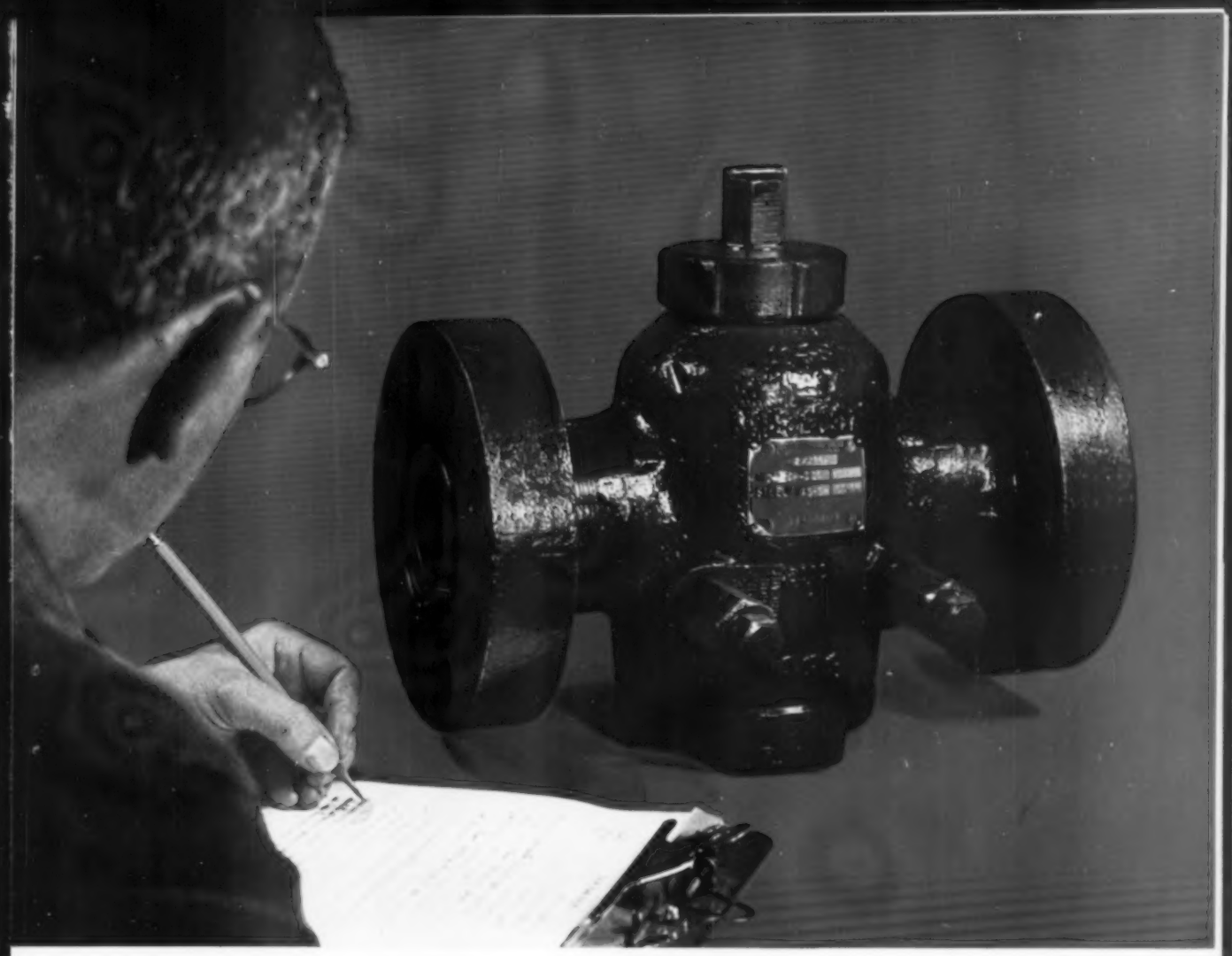
***LEBUS COUNTERBALANCE SPOOLING**

Patent Nos.: Counterbalanced Spooling, Nos. 2,734,695; 2,732,150. Controlled Parallel and Helical Spooling, Nos. 2,708,080; 2,620,996. Appli. of grooving, Nos. 2,599,926; 2,204,938. Removable End Fillers, No. 2,216,819. Other patents pending.

LeBus International Engineers

Executive Offices, Sales, Services & Warehouse • Longview, Texas

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



17 Years Old- Still Going Strong

After 17 years this Mission Plug Valve is ready for another long period of service

THIS MISSION PLUG VALVE bears the serial number 100. It was built in 1940 and for the past 17 years has served on the fill-up line of a blowout preventer on a South Louisiana rig.

It is shown here just before it was shipped back to the customer after being reconditioned by Mission. It again carries a new valve guarantee as do all Mission factory reconditioned valves.

Records show that it has been reworked only once during the last 17 years — a record seldom equalled by other types of valves.

Performance like this is not unusual for Mission Valves. Automatic Lubrication literally stops leaks before they start, preventing valve damage and increasing useful life. Because of their long life and freedom from maintenance, Mission Plug Valves are especially suitable for Christmas Trees, gathering systems, cycling plants and pressure maintenance plants.

Be sure to specify the name Mission the next time you order plug valves. They are available through supply stores everywhere.

Nothing but the finest will bear the name of MISSION MANUFACTURING CO

MISSION MANUFACTURING CO. • P. O. Box 4209 • Houston, Texas • Cable Address—"Missco" • Export Office: 30 Rockefeller Plaza, New York
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SLUSH PUMP VALVES • PISTONS • VALVE SEAT PULLERS • LINERS • PISTON RODS • VALVE SPRINGS • GLAND PACKINGS • SLIPS • SWABS • PLUG VALVES • CENTRIFUGAL PUMPS

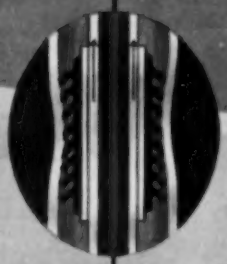
FOUR REASONS WHY

MISSION E-Z SWABS

are fast, safe and economical

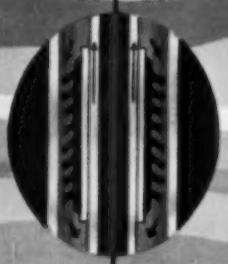
1. FREE FALLING

On the down stroke, clearance between fins and pipe allows swab to fall free.



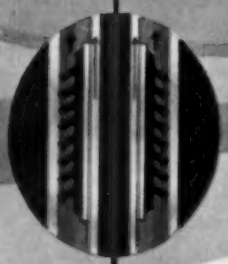
2. PASSES SMOOTHLY THROUGH TIGHT SPOTS

Flexible E-Z Swab Rubber fins allow swab to pass smoothly through tight spots on both up and down strokes.



3. RELEASES OVERLOADS

When load is excessive, fins bend down to bypass excess fluid. This safety relief action prevents overloads and broken wire lines.



4. LONG LASTING

After overload is bypassed, fins spring up until they seal. Wear is slow because fins seal against pipe with light contact pressure.

Nothing but the finest will bear the name of

MISSION MANUFACTURING CO.

Mission E-Z Tubing and Casing Swabs are made in seven popular sizes (1½", 2", 2½", 3", 4½", 5½", and 7"). They are available through supply stores everywhere. Be sure to get a Mission E-Z Swab before your next swabbing job.

PESA

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GUIBERSON'S FULL RANGE
of High and Low Pressure, Quick Change
UNIONS

1,000 lb. test
2,000 lb. test

4,000 lb. test
6,000 lb. test
10,000 lb. test
15,000 lb. test

Quick and easy to make or break, Guiberson's Unions are ideal for a multitude of uses... give a positive, leakproof seal, with minimum upkeep. Guiberson's low pressure unions 1" through 10" sizes have metal to metal seats, feature a convenient 3-lug wing nut.

High pressure unions are made in 1" through 4" sizes. 6,000 lb., 10,000 lb. and 15,000 lb. unions incorporate the pressure-molded Seal-O-Matic Ring. All high pressure unions are forged steel.

THE
GUIBERSON
CORPORATION

ESTABLISHED 1919
DALLAS, TEXAS
U. S. A.

Sold by
Oil Field Supply Stores
Everywhere

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for successful fracturing
of your well...

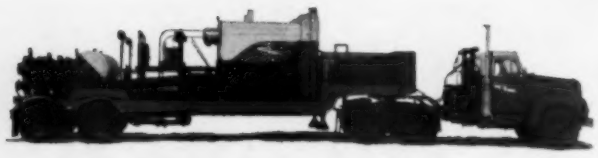
CHECK THE PROPERTIES OF HALLIBURTON'S

VIS-O-FRAC

Base Fluid	Crude oil or light refined oils
Gelling Agent	Soap formed in situ
Method of Field Mixing	Batch or continuous
Type of Finished Fluid	Non-Newtonian gel • not an emulsion
Method of Viscosity Reduction	Easily diluted to low viscosity by formation oil
Fluid Loss Properties—API Code 29	Will vary with base fluid but normally will be 10-45 cc. Can usually be lowered with low fluid loss additives to 5-15 cc.
Temperature Stability of Fluid	Slight decrease in viscosity with increase in temperature. Viscosity index much higher than the base oil.
Sand Transporting Characteristics	Good • falling rate very slow. Normally, 1-3 lbs. per gallon is used.
Types of Formations Best Suited	Oil and gas bearing formations.

To stimulate production in your reservoir, Halliburton's VIS-O-FRAC offers you these benefits:

LOW FRICTION LOSS • GOOD SAND TRANSPORTABILITY • ECONOMY



Use VIS-O-FRAC for your next fracturing treatment. Talk to your local Halliburton representative for more information.

HALLIBURTON OIL WELL CEMENTING COMPANY
DUNCAN, OKLAHOMA

THE PIONEER IN FRACTURING SERVICES

251 SERVICE CENTERS — JUST MINUTES AWAY FROM YOUR WELLS

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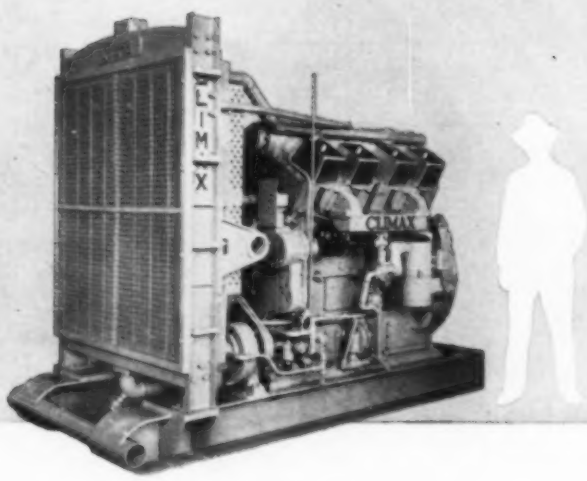
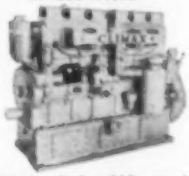
THE BIG FEATURE ABOUT CLIMAX ENGINES
IS THE **OWNER SATISFACTION**
THEY PROVIDE . . . .



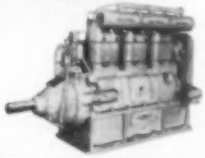
A Complete Line of Oil Field Engines up to 605 H.P.

V-125—12 cylinder, 605 max. H.P. at 1200 R. P. M.
V-122—12 cylinder, 520 max. H.P. at 1200 R. P. M.

V-85—8 cylinder, 390 max. H.P. at 1200 R. P. M.
V-80—8 cylinder, 340 max. H.P. at 1200 R. P. M.



K-75—6 cylinder, 302 max. H.P. at 1200 R. P. M.
K-67—6 cylinder, 265 max. H.P. at 1200 R. P. M.



R-165—6 cylinder, 192 max. H.P. at 1200 R. P. M.
R-110—4 cylinder, 130 max. H.P. at 1200 R. P. M.

. . . MIGHTY IMPORTANT TO CONSIDER WHEN YOU BUY AN ENGINE!

Here's why Climax Engines are so "owner satisfying"—

You get an engine that will give years of service on any job . . . whether powering drilling rigs, pumps, compressors or generators.

—an engine designed for easy starting . . . simplified operation . . . equal efficiency on natural gas, butane or gasoline by merely closing one set of valves and opening another . . . easy maintenance . . . readily accessible operating parts and accessories.

—an engine backed by prompt service throughout the oil country . . . friendly Climax Distributors offering a complete stock of parts, repair facilities and factory trained mechanics.

—these, plus many other Climax advantages, add up to owner satisfaction . . . the kind you get when you buy Climax Engines!

See, call or write your nearby Climax Distributor today!

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LANDES, ZACHARY AND PETERSON
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TOOHN MACHINERY CO.
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UNITED POWER, INC.
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Coolidge and Casa Grande, Ariz.

SHRIMPTON MFG. AND SUPPLY CO.
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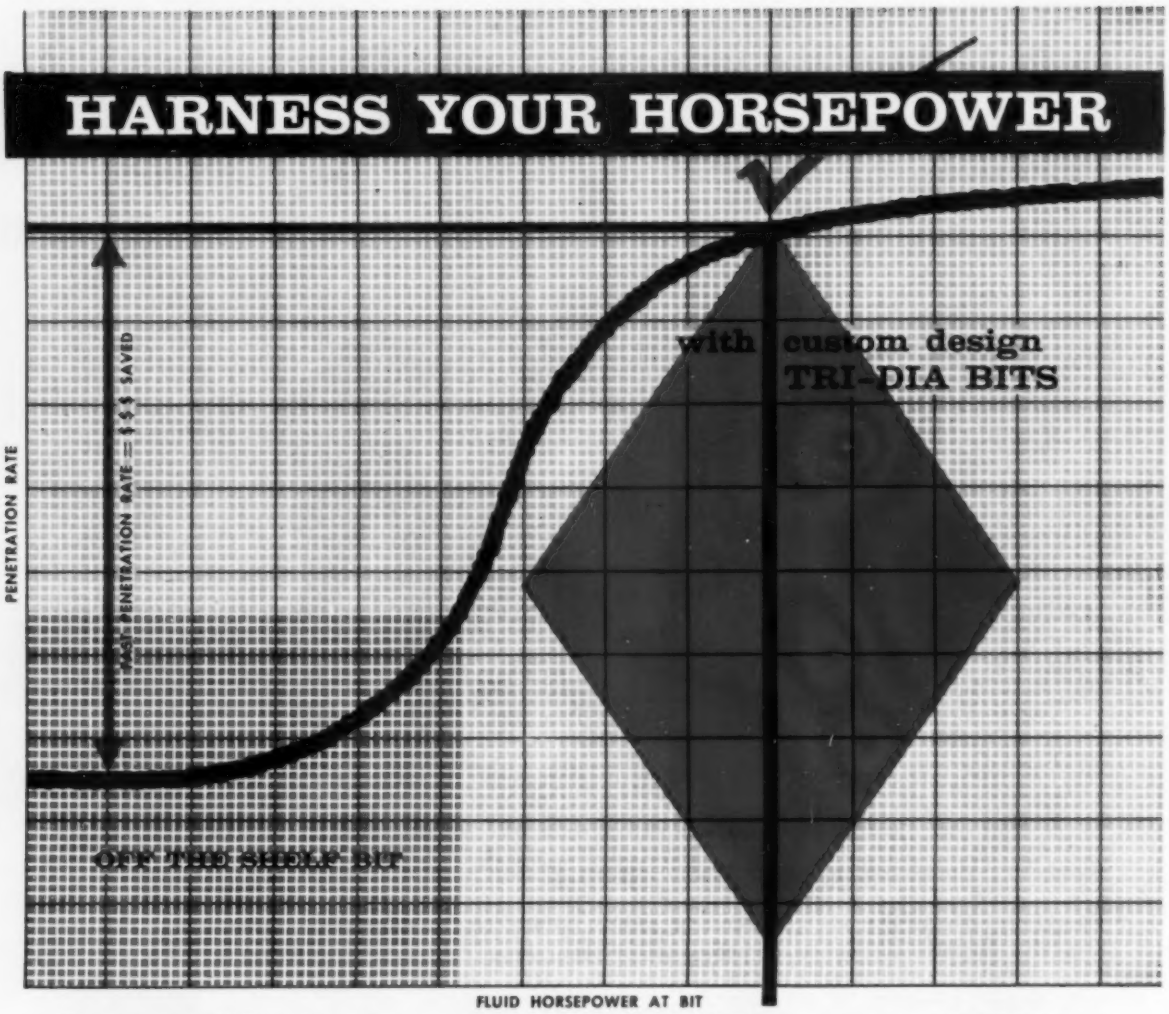

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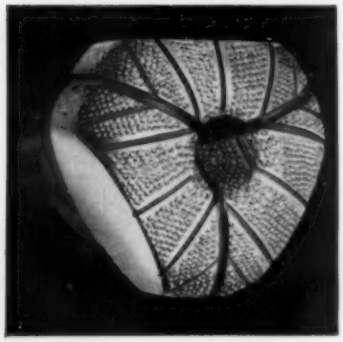

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Engine HP (net)..	72 (80 Gross)	63	66.5	66
Torque Converter	YES	NONE	NONE	NONE
Max. lbs. push or pull	20,000*	10,700	15,485	12,600
Forward Speeds, MPH	(4) 0 to 6.0	(4) 1.5 to 6.1	(4) 1.5 to 5.5	(4) 1.7 to 5.9
Reverse Speeds, MPH	(4) 0 to 7.0	(2) 1.7 to 2.6	(2) 2.0 to 4.1	(2) 1.9 to 3.9
Power-Shift Transmission ..	YES	NONE	NONE	NONE
Power-Steer	YES	NONE	NONE	NONE
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Here is a mud valve that was designed, built, and sold for one purpose—to handle oil drilling muds efficiently and economically regardless of the sand content or lost circulation material. It's a big order, but MUDWONDER valves take it in stride.

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Why The MUDWONDER Gives Mud Valve Economy

A hard chrome gate which is separate from the stainless steel stem plus a buna-N(Hycar) seat insert integrally molded over steel wear rings combine to resist abrasion—give long, dependable service.

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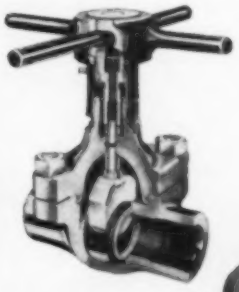
- **Keeps mudlines intact**
- **Operates easier, faster**
- **Seals drop tight**
- **Stops sanding**
- **Cuts maintenance**
- **Slashes downtime**
- **Assembles easily**



Here is the wear-absorbing heart of the MUDWONDER. Hard-chromed gate in combination with buna-N seat molded integrally over steel wear rings resist abrasion.

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Baker Retainer Production Packers have many important advantages . . . Meet dimensional requirements of Permanent-Type Well Completions; provide permanent, reliable pack-off which will hold against any pressure differential (from above or below) that is safe for the casing; Tubing String is free because neither set-down tubing weight nor tubing tension is required to achieve and maintain pack-off, although the tubing may be anchored to the packer if desired; Tubing String readily removed. Packer can be set on a wire line; is readily drillable, and can be used as either a Squeeze or Production Tool.

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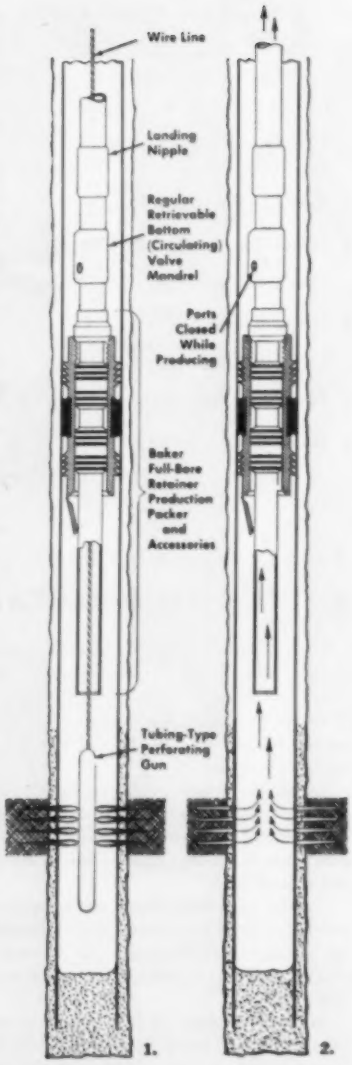


One of the many types of Permanent-Type Completions is shown above. After perforating (1) and retrieving the cable head and collar locater, the well is put on production (2). All subsequent work-overs, such as squeeze cementing to improve gas/oil ratios, are conducted with special tools which are run through the tubing string.

FIG. 1. **Perforation pattern** of fracture initiation process to actual scale through a horizontal plane. Key to controlled fracture is the critical ratio of perforation diameter to distance between perforations. ◆

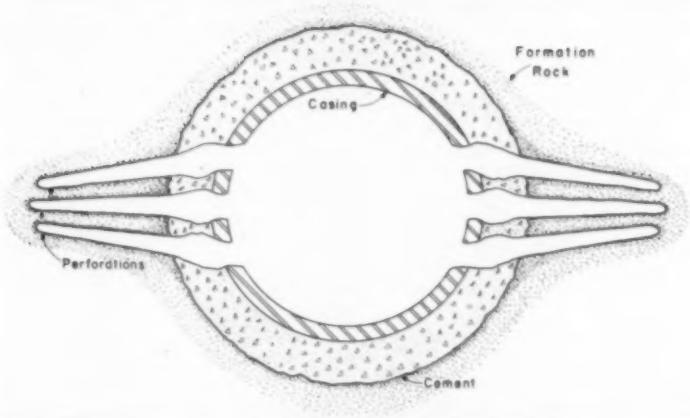


FIG. 2. **Special jet perforator** currently used in the field to create desired stress pattern in formation rock. Note how outer charges are directed inward toward center charge to offset tapering of jet perforations so that they will be essentially parallel. ◆

New Process Initiates . . .

Formation Fractures In One Controlled Plane

Stress concentrations created in formation rock by three essentially parallel perforations in opposite sides of the casing and in a common plane permit control of the direction of a single fracture

J. E. Kastrop,
Editor

FIFTY-two actual field tests and a host of surface experiments preceded by two years of research indicate that a formation fracture can be initiated and controlled in any desired plane within the wellbore. Referred to as the "fracture initiation process" by its developers, The Western Company of Midland, Texas, success of the new idea lies in two key features: (1) Establishing stress concentrations in the formation rock in the desired plane; and (2) initiating the fracture with an extremely low fluid-loss material.

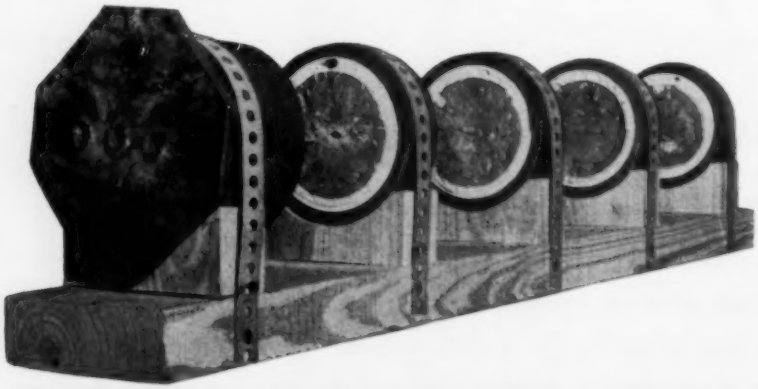
Concentration of stresses in a single plane, either vertical or horizontal (or at any angle in between) that initiate the fracture in the desired direction is accomplished by a single set of six perforations in that plane as indicated in Fig. 1. Three perforations are grouped together on one side of the casing while the other three perforations are made on the opposite side of the casing. The secret of setting up concentrations of stress in the rock along a plane intersecting the centers of the three parallel perforations on either side of the wellbore is the critical ratio of the distance between the perforations and their diameter.

Special jet perforator used. To set up stress patterns in the formation so it will fracture in a controlled plane, a special jet perforator was designed. It contains three opposing shaped charges held together by an aluminum cross bar as shown in Fig. 2. Outside diameter of the aluminum housing is 4.4 in. About 11 grams of compressed RDX explosive make up each of the six shaped charges. Note that the outer charges are directed slightly inward towards the center charge to create three perforations essentially parallel to each other. All six charges are initiated simultaneously by three strands of primacord of equal length. The housing is shattered completely below the necked-down section under the coanecting thread. Approximate diameter of the perforated hole in the casing is 3/8-in. to 7/16-in.

Breakdown fluid important. Following (or before) perforating, a specially-prepared breakdown fluid, usually

made from lease crude, is spotted across the zone to be fractured. Formation breakdown is then accomplished by injecting fluid into the well until the break occurs. Pumping fluids into the fracture should continue to exert stress on the extremity of the fracture causing it to split and propagate in the same direction (much as splitting a cake of ice using an ice pick to start the crack in the plane desired). If none of the fracturing fluid leaks off to build up pressure in adjoining or intersecting cracks or crevices, propagation of the fracture in the direction initiated should be expected. If some or all of the frac fluid bleeds off into adjoining cracks of fissures, then another fracture may be expected to be opened and propagated in addition to, or instead of, continuing the initiated fracture.

The selection of a breakdown and frac fluid is important. The fluid should be designed so that it can penetrate the fracture initiated *and nothing else*. A special breakdown fluid has been designed for this purpose. It is desirable but not always necessary that the frac fluid also be specially treated.



Perforated dolomite core, but not fractured. Core was cemented in casing with a mild steel face plate. After perforating, target was cut into sections and separated. Note that a horizontal fracture was created by the stresses set up in perforating, as shown clearly in the third section.

Why Control Formation Fractures?

Since the early concept of hydraulic fracturing, efforts have been made to control the fracture pattern. A single, deep, horizontal fracture is desirable in relatively thin producing zones containing either a gas cap or water table or both. A horizontal controlled fracture in the oil zone eliminates excessive production of water or gas. This aspect of controlled horizontal fracturing is of equal importance in relatively large producing intervals characterized by either an effective gas cap drive or effective water drive or both, where it is desired to exclude production of both. Even thin zones can be fractured in this manner without extending the fracture into an adjacent barren zone.

Vertical communication outside the casing can be reduced considerably by one set of perforations in a single horizontal plane. Fewer holes are required to establish adequate communication between the wellbore and the producing formation by a deep, penetrating, controlled horizontal fracture.

In certain cases where there exists thin multiple pays separated by thin sections, it may be more desirable to create a vertical fracture to intersect more than one pay zone to obtain maximum production.

The control of a single fracture in any plane has many advantages, and whether it is vertical or horizontal will depend upon the reservoir. If multiple pay zones are separated by considerable distances, each reservoir can be treated individually. This has been done successfully in a recent case in California where multiple pays are common.

Previous attempts to control fracture. A number of attempts have been made to control fractures. An early attempt was made to create horizontal fractures in squeeze cementing. This trial consisted of firing four shots spaced 90° apart on the same horizontal plane. Purpose was to obtain cement 360° around the casing and eliminate vertical migration of fluid.

Another attempt was made to create vertical fractures by perforating through casing with 4 shots per foot arranged in a vertical plane linearly along one side of the gun. These attempts, while certainly a step in the right direction, did not achieve completely the results desired.

Proving merit of idea. Although considerable research indicated the desirability of parallel perforations separated a critical distance apart, every conceivable perforating method to create a fracture plane was investigated.

Fig. 3 through 7 show some of the surface tests conducted. Large concrete targets measuring 5 ft in diameter and 3 ft thick were poured around sections of 5½-in. J-55, 17-16 casing. After hardening, the casing was perforated by several different perforating patterns and the target hydraulically fractured by normal fracturing procedures. Included in this series of tests were the fracture initiation process to induce horizontal, vertical and even 45° fractures.

Results showed that the four perforations in a horizontal plane offered no control over the fracture plane. This was essentially true in the case where eight radial perforations were made 45° apart around the casing in a horizontal plane. However, this test did indicate that the degree of control of the fracture plane was considerably improved over the four-jet pattern, but it was still eratic and unpredictable. The fracture initiation process tested on these large concrete targets did verify previous findings that a vertical or horizontal and even a 45° fracture plane could be initiated in a nonuniform material such as concrete.

Are Six Perforations Adequate?

The question as to how many perforations will adequately produce a well is almost as old as perforating itself. In relatively uniform formations *that are not fractured*, reservoir drainage can be improved by increasing the number of casing perforations throughout the productive interval. But, when hydraulic fracturing is considered, the picture changes radically. Why? In the unfractured reservoir, the increased perforations simply increase the number of shallow pipelines into the wellbore.

When the formation is fractured and the crevice created filled with sand, a vast pipeline network is set up in the reservoir surrounding the wellbore and vastly extending the drainage area around the fractured well. Formation exposure via the wellbore is relatively small as compared to exposure area in fractures. For example, in an uncased hole 100 ft thick and 7⅞-in. in diameter, the exposed surface area is about 200 sq ft. In a single horizontal pancake fracture of 100-ft radius (not unreasonable in fracture treatments), the exposed surface area is 62,834 sq ft (considering top and bottom area of pancake fracture); or about 300 times greater than the exposed area in a 100-ft section of open hole. This is the old

FIG. 3. **Controlled horizontal fracture** made in large concrete target by fracture initiation process during surface tests. 5½-in. casing was cemented in center of 5-ft diameter block, 3-ft high.

FIG. 4. **Controlled vertical fracture** made in concrete target by fracture initiation method. After fracturing, target was separated to show how fracture plane intersects all six perforations.

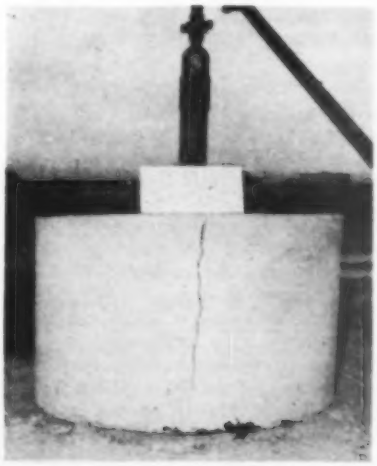
success story of fracturing from the very beginning.

Perforations in fracturing. "How many perforations in a fractured well to provide adequate well drainage?" In conventional fracturing, the number of perforations is not a critical item, except it was common practice to saturate the desired zone with perforations. But, experience indicated the wisdom of keeping a safe distance from both gas and water.

Much could be and has been written about the extent of fractures created during well treatments. It is logical . . . and this point has been substantiated by field experience . . . that a given frac treatment in a few perforations will extend the formation fracture further than the same frac treatment through a larger number of perforations. Here, the question comes up: "Will a few perforations provide satisfactory productivity even though an extensive fracture has been created?" Previous studies have shown that for each zone of permeability, a single deep penetrating fracture provides more effective reservoir drainage than several shallow penetrating fractures. These conclusions are being substantiated every day by field results. Bruce Gilbert, research associate at The Western Company's research laboratory in Dallas, Texas, and the inventor of the fracture initiation process, points out that a single, deep penetrating fracture will adequately drain one producing zone as much as 50 ft in thickness if there are no permeability barriers.

In one field in New Mexico, the reservoir had an effective gas cap and

FIG. 5. **Resulting vertical fracture** when target was perforated by four charges spaced 90° apart in a horizontal plane.



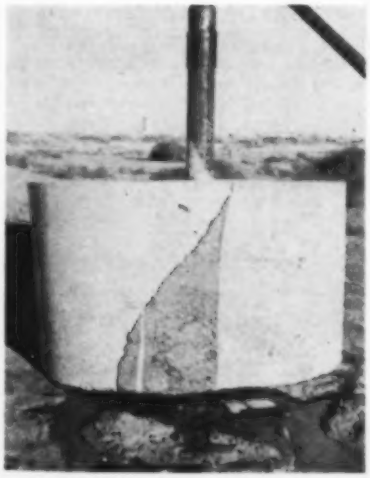


FIG. 6. **Single jet perforation** from standard 4-in. gun and subsequent fracture treatment made this S-shaped fracture. Dark area on outside of target is fracture fluid.

FIG. 7. **Fractured concrete target** when centrally-located 5½-in. casing perforated with standard gun containing 4 shots per ft and then treated. A 1-ft section of the 4-in. gun containing 4 charges was used.

water drive. Permeabilities were quite low and fracturing was necessary. Normal fracturing procedures over an extended interval resulted in high GOR and large water production which necessitated subsequent workovers. Three wells in this field were perforated with the six-shot jet gun within 50 ft of the water table, and fractured with the usual amount of material for this area. After treatment, all three wells produced little water, and GOR was low.

In a southwest Texas field, normal pumping production was from 2 to 8 bbl daily per well. The pay section was only 8 ft thick but the reservoir contained ample reserves. One well was treated by this new fracturing process and 90,000 lb of sand injected into a controlled horizontal fracture. After more than two months following treatment, the well was flowing 41 bbl per day at 290 psi flowing pressure through an 8/64-in. choke. Casing pressure was 570 psi.

Fig. 8 shows results of several studies on oil production rates through perforations. For example, 2300 bbl per day can be produced through the six perforations with a differential pressure from the reservoir into the wellbore of only 5 psi.

Injection rate through six holes. Are six perforations adequate to accommodate higher injection rates now used in fracture treatments? Fig. 9 shows results of a simulated field test where a section of 5½-in. J-55, 17-lb casing was perforated with the six-shot jet gun used in the fracture initiation process. Fracturing material consisted of 2 lb of sand per gal of 42-gravity API crude oil. An injection rate of 20 bbl per min was attained at a differential across the six perforations of only 900 psi. In one recent field test, 90,000 lb of sand were pumped through one set of six horizontal perforations without difficulty . . . and, there was no indication of sand bridging in the casing. Sand concentrations up to 3 lb per gal have been used in this process without difficulty. Apparently the higher velocities through each of the six perforations prevents sanding up.

Breakdown pressures lower. After development of the practical features of the fracture initiation process, it was taken into the field and 52 treatments on actual wells in various areas and producing formations were made. Some impressive results were obtained in reducing water production and GOR with appreciable increases in oil production. Of significance here is the fact that lower breakdown pressures were noted in many instances. Tests in South Texas showed a breakdown pressure of 1000 psi less than normal; in one West Texas field where normal breakdown pressure is about 6800 psi, the formation broke down at 3800 psi with the new method. Laboratory studies indicated this characteristic before it was verified in the field. Fracture pressures in these laboratory tests were reduced from 2000 psi for a single hole to 600 psi for three holes drilled into the test material at the critical spacing.

Stress Analysis was Criteria

Extensive stress studies were made to determine the geometry of the perforating pattern such that when subjected to hydraulic pressure, a plane of weakness was created within the test material. Stress testing of material was preceded by thorough mathematical analysis. It was interesting to note that subsequent laboratory stress studies verified results indicated by calculations of hoop tension in thick-walled cylinders. Fig. 10 shows how photo elastic studies were used extensively in the development of this idea.

To induce a fracture, the size and spacing of the holes made are critical. Fig. 11 illustrates results of a series of tests conducted to evaluate this factor. This test utilized a large number of molded plaster cylinders 12 in. in diam-

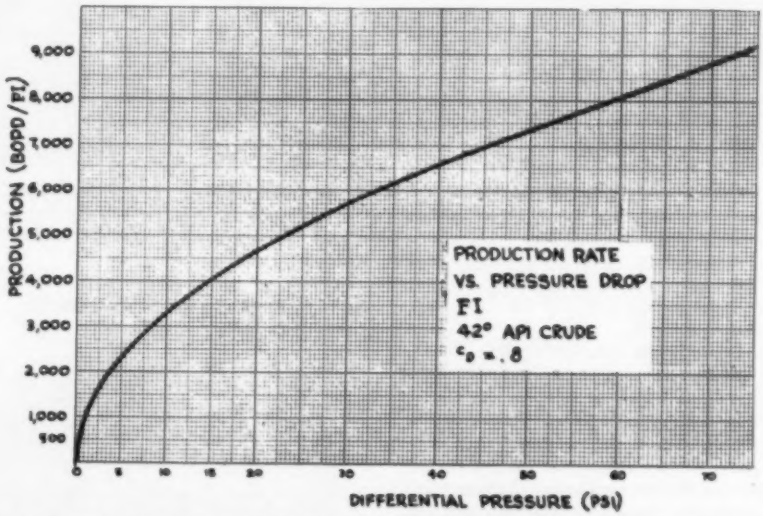


FIG. 8. **Production rate possible** through six perforations in casing for varying pressure differentials across the perforations. A 10 psi differential will flow 3300 bbl of 42-gravity oil per day through the six holes made in casing by this new perforating gun.

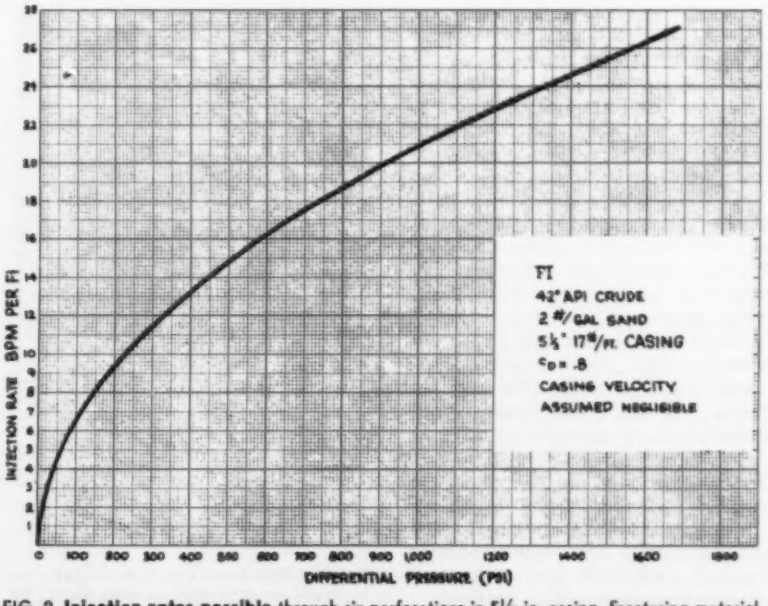


FIG. 9. **Injection rates possible** through six perforations in 5½-in. casing. Fracturing material consisted of 2 lb sand per gal of 42 gravity crude. Curve shows that with a 900 psi differential across the six perforations, an injection rate of 20 bbl per min is possible.

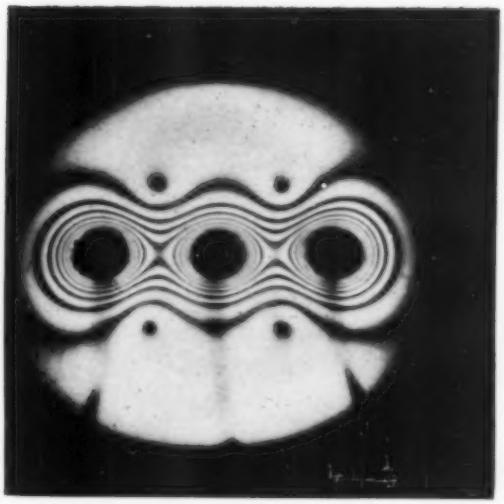


FIG. 10. **Photo elastic studies** verified validity of critical ratio of hole diameter to hole spacing in creating a plane of weakness through three holes. Shadow rings around optic plastic specimen represent lines of stress when hydraulic pressure was applied inside the three holes. Four black dots indicate neutral stress points.

eter and 10 in. long. Cavities were drilled into the flat end face. Hydraulic pressure was applied to the cavities using packers manifolded together to maintain equal pressures in all holes. The pressures required to fracture the models and the degree of control of the fractures was measured and correlated with the number of holes, depths of holes, hole diameters and space between holes.

Fracture pressures varied between 2000 psi required to fracture from one hole and 600 psi required to develop a controlled fracture. Until the holes were sufficiently close together, random fracturing occurred. A high degree of control was achieved by using the proper spacing. The models used for these tests were made of plaster and the holes used were uniform. Obviously, the critical hole-size-to-spacing ratio will be different for each type of reservoir rock, for each depth, etc. Exhaustive tests were conducted in surface outcrops in an effort to evaluate this factor as thoroughly as possible before attempting well tests. They were conducted to develop a spacing which would provide the desired results in a great majority of cases encountered.

Adjustment has been made to bring the holes close enough together to produce the stress concentration needed without causing spalling or shattering of the rock material between the holes (thus changing the stress concentration).

Recommended uses. Recommended applications of this new fracturing idea is primarily for initial completions and recompletions in zones where the casing has not been previously perforated. It is not recommended at this time for treating wells that have been shot with nitroglycerin or similar bulk explosives, in zones previously fractured by conventional methods, in or near zones that have been squeeze cemented, or in conventionally perforated intervals or heavily acidized sections.

To date, the fracture initiation process is not generally recommended for open hole zones, although development is continuing in this direction. In 15 field tests to control a fracture in the open hole interval, 8 jobs were successful and 7 were regarded as failures as determined from spinner and radioactive tracer surveys. Successes experienced to date in controlling a fracture in open hole sections have been in areas where the exposed formation is fairly homogeneous, such as consolidated sandstones. Failures in attempts to control the fracture in the open hole were noted in wells where the rock strength in the exposed section varied widely.

Current development. Developers of this new fracturing idea look upon the current state of development as the threshold of an entirely new concept in hydraulic fracturing. Development continues in all phases associated with the process, from the tools used to field applications. Preliminary field tests to employ this idea as a sand exclusion method in unconsolidated sands has met with some success. It can be used in multiple stage fracture treatments by means of perforation ball sealers. It offers considerable possibilities in squeeze cementing techniques. Undoubtedly, numerous other applications will become known as its use widens.

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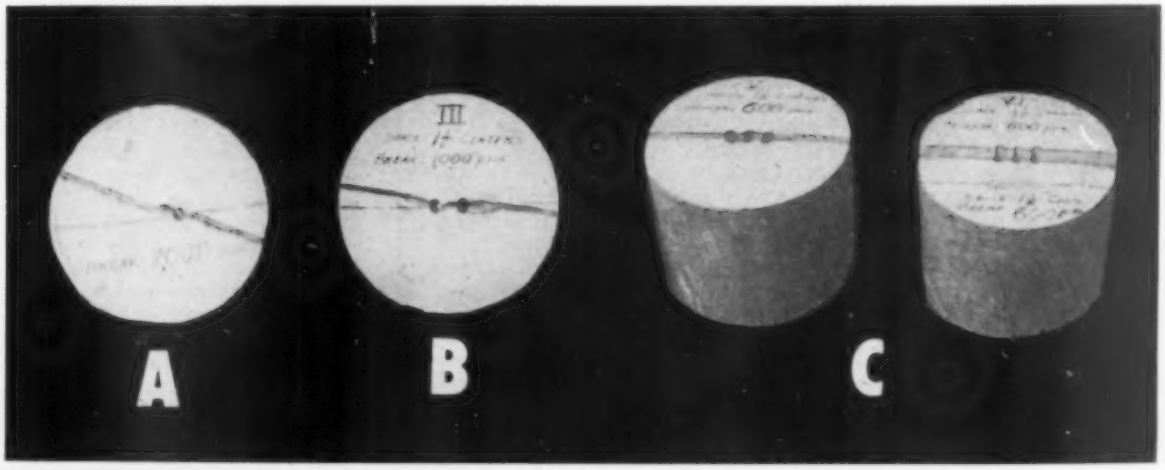

FIG. 11. **Fracture patterns** in 12-in. diameter by 10-in. long homogeneous plaster molds drilled with ½-in. holes. **A.** Uncontrolled fracture from single hole required 2000 psi to rupture. **B.** Fracture resulting from two holes; breakdown pressure was 1000 psi. **C.** Two molds fractured along plane through center of three holes drilled into specimen at critical hole-diameter-to-hole-spacing ratio. Breakdown pressure: 600 psi.

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AUDREY 1200 CST JUNE 25 1957
A HURRICANE WATCH IS ADVISED FOR THE TEXAS AND LOUISIANA COAST.
NAVY RECONNAISANCE INTO THE SOUTHWEST GULF OF MEXICO THIS MORNING INDICATES THAT THE TROPICAL DEPRESSION HAS INCREASED RAPIDLY AND IS NOW A HURRICANE. AT 1200 CST . . . 1800Z . . . HURRICANE AUDREY WAS CENTERED NEAR LAT 22.5 LONG 93.0 OR ABOUT 380 MILES SOUTHEAST OF BROWNSVILLE, TEXAS. IT HAS MOVED VERY LITTLE DURING THE LAST 12 HOURS. HIGHEST WINDS ARE ESTIMATED ABOUT 75 MPH IN A SMALL AREA NEAR THE CENTER AND GALES EXTEND OUTWARD 100 MILES.
HURRICANE AUDREY IS EXPECTED TO MOVE NORTHWARD ABOUT 5 MPH DURING NEXT 12 TO 18 HOURS AND INCREASE SLOWLY IN SIZE AND INTENSITY.
ALL INTERESTS ALONG THE TEXAS AND LOUISIANA COASTS AND IN GULF OF MEXICO SHOULD WATCH FOR LATER ADVISORIES.
NEXT ADVISORY WILL BE ISSUED AT 4 PM CST.
CONNOR WEATHER BUREAU.

Part 1

WITH this teletyped message Hurricane Audrey was born. Before the season's first tropical disturbance had spent its destructive force across Louisiana, a small portion of Texas, Mississippi, Arkansas and Tennessee, 18 such Weather Bureau advisories were issued to chart its force, velocity and movement.

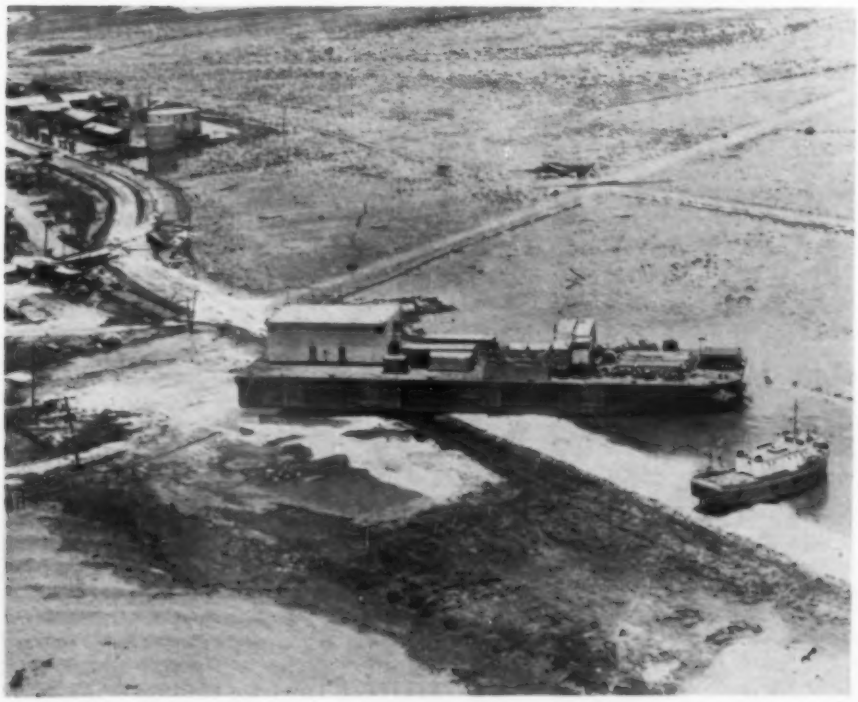
For a "season opener," Audrey set a record. It has been many years since the Gulf Coastal states have counted such a tremendous loss in life and property in one hurricane.

Storm Path

Audrey was first spotted as a "tropical depression" in the Gulf about 300 miles southeast of Brownsville, Texas, by the New Orleans Weather Bureau at 10:30 p.m. (CST) on June 24. The first weather advisory indicated winds of only about 35 to 40 mph (as noted at point of origin on map). Each of the many following weather bulletins noted its intensification and slow northward movement. By the third advisory, however, it had reached hurricane proportions with winds of 75 mph; this was at noon. June 25. It was at this point "Audrey" got its name. Gales from the hurricane's center extended some 200 miles and first touched offshore installations along the upper Texas and Southwest Louisiana Gulf Coast area in the early morning hours of June 27.

Heavy rains of 4 to 8-in. accompanied the storm into the coastal area

This was Cameron, Louisiana — where many oil employees were sent home to care for families and ride out the storm. Full fury of the storm was unleashed here and losses in property and life were heaviest.



High and dry — but slightly damaged. Brewster-Bartle Drilling Company's supply barge from the company's Rig 3-A was lifted by the hurricane from the nearby Intracoastal Canal and set on the road into Cameron.

with high tides estimated at 9 ft. Center of Audrey passed inland at the Louisiana-Texas border with high winds and squalls occurring over extreme East Texas and most of Louisiana. Highest official wind speed of 105 mph was recorded at Lake Charles, the Weather Bureau reported. The storm waned in strength on its course northward through northeast Louisiana, northern Mississippi and southeastern Arkansas in the early hours of June 28. By 4 p.m. of that day center of the disturbance was near Memphis, Tennessee, clocked with wind speeds of 40 mph, later blowing and raining itself out over the upper Ohio Valley, although some "torrential rains and severe thunderstorms" were attributed to Audrey in southern Michigan, East Central Illinois with some disturbance extending into western Pennsylvania and western New York.

Oil Property Damage

"Lucky" is the best way to describe the oil industry's bout with Hurricane Audrey. Property damage appears relatively slight to oil installations even though it ripped through the heart of southeast Louisiana's oil and gas producing areas. "On-duty" loss of life from Audrey was practically nil, although little is known of the whereabouts of some employees sent home to care for their families. Total death toll in the Cameron, Louisiana, vicinity now stands above 300. Several oil industry employees are among the number.

Drilling and production work, although placed second to general rescue and cleanup operations, began to resume in as few as 48 hours after Audrey hit the area on June 26 and 27.

Refinery and gas processing operations in some instances did not so much as pause during the hurricane. Others were shut down 48 to 72 hours. Losses in crude runs were estimated at near 100,000 bbl, which would probably not be made up, although one crude buyer was quoted as saying that: "I doubt if that would do much violence to the crude market, which is so bad it hardly could get much worse."

Losses 'Small'

Perhaps one of the biggest factors behind the small oil property loss was quick heeding of hurricane warnings by the U. S. Weather Bureau. Most installations were braced and battened down for the storm, and personnel withdrawn and released from duty well in advance of Audrey's onslaught.

Biggest single loss was sustained by John W. Mecom, independent Houston producer. The company's $2,000,000 mobile rig "Ed Malloy" has been classified a total loss. The rig, made up

of a converted floating drydock and a drilling barge, separated and the drilling barge sank. It had been operating off Cameron, Louisiana, and bore full brunt of the storm.

Drilling Structures Fare Well

Also in the path of the Hurricane was Zapata Off-Shore Drilling Company's "Vinegaroon." The tripod mobile platform rode out the storm "beautifully," although it settled seven feet vertically at its location in 35 ft of water at Sun Oil Company's No. 1 Louisiana State Lease 1383, about 18 miles southeast of Cameron. Evacuation of the platform was complete before Audrey struck — the crews even taking along the typewriters and other small equipment. Drilling on the "Vinegaroon" resumed July 2.

Most self-contained platforms in the area sustained little or no damage in the 100 mph-plus winds and 5 to 9 ft high tidal waves. Two such platforms belonging to Superior Oil Company were left listing, one 8 deg; the other reportedly 15 deg in the wake of Audrey. Equipment from one of Superior's platforms is being moved to permit repairs; the other was leveled intact and put back into operation.

Two submersible inland drilling barges belonging to Southeastern Drilling Company were sunk. These were immediately raised and put back into operation.

The Offshore Company's Rig 54, drilling in 101 ft water in Block 164, Vermilion area, for the California Company, sustained "minor" settling and superficial damage. Drilling was resumed in a few days.

Kerr-McGee Oil Industries Rig 40 suffered extensive damage of deck equipment. Wave action worked the mobile unit into the ocean floor until water broke over the platform and caused a slight list. Three other Kerr-McGee rigs operating near Cameron reported no damage.

Several drilling tenders on location in the storm area broke loose or were cut from moorings and run aground during the storm. Four tenders operating at CATC Group locations were pushed aground about five miles east of Cameron by the storm. Two of the vessels, belonging to Reading and Bates Drilling Company, were sent immediately back to well locations and drilling continued. Of the two CATC-owned tenders, one was sent back to location and one was towed to drydock at Orange, Texas, for repair to water-soaked crew quarters and routine repair.

The hurricane tried to undo damage left by previous storm action. C. G. Glasscock's "Mr. Gus," which was undergoing salvage following storm damage inflicted a few months ago, was set upright by Audrey from a tilted position.

Crushed, toppled and rearranged tank batteries were common sights in the Cameron area. Escaping gas and fluid, as shown here, were all part of the common scene. Uncontrolled wells and broken flow lines necessitated remedial work and repairs initiated immediately.

Production Damage Scattered

Offshore producing platforms suffered minor damage, primarily limited to flow lines, stairways and dolphins. Wellhead equipment damage, toppled tanks and separators, flattened field houses and outdoor equipment were not uncommon sights throughout inland areas from High Island to Cameron and north to Lake Charles. Several production derricks onshore were blown to the ground. Pipeline and flow line damage was held responsible for considerable crude losses in and near Cameron.

The entire Cameron area was declared uninhabitable for three weeks following Audrey.

A loosed barge in the Weeks Island area was responsible for causing a Humble Oil & Refining Company well to blow wild. Some wells in the Cameron area were reported out of control for several hours, however some of the wells sanded up to a small flow and others were brought under control. Sohio Oil Company reported loss of several tank batteries in the Creole area and part of a gas compressor station at Holmwood.

Refinery Losses Small

Refineries in Lake Charles and as far west as Port Arthur experienced some damage. At Port Arthur, Gulf Refining Company's refinery was shut down and received some damage. The Continental Oil Company's refinery at Lake Charles counted the loss of two partially-constructed concrete coke silos. Cities Service Refining Corporation's Lake Charles plant estimated $50,000 damage from ripped aluminum and steel sheeting due to gusts of high wind.

Oil to the Rescue

Oil industry boats, barges, planes and helicopters, as well as field roustabout crews, figured prominently in rescue, evacuation and clean-up operations. A CATC crew boat was said to be the first to arrive in Cameron to evacuate survivors and bring in food and supplies. Tenders and barges representing nearly every offshore operator were included in the effort. Two CATC helicopters, with Conoco pilots, aided in rescue operations. Magnolia Petroleum Company's helicopter, piloted by Travis Rhodes, began efforts to locate survivors soon after Audrey struck and was later called on to help coordinate helicopter and National Guard work and also took out injured persons.

Oil marsh buggies were later called

in to help locate survivors, deliver food and even round up stray cattle.

How Many Audrey's?

Audrey was just the first of some 20 anticipated named gulf hurricanes that will brush the coastline of the continental U. S., say the meteorologists.

Some of these weather experts say that this first hurricane of 1957 is just a taste of what is yet to come. According to observers who follow the weather cycles, this year may be THE big year.

The oil industry found wells, rigs, platforms and equipment withstood Audrey's gales and tides splendidly. Construction engineers calculations for building coastal equipment for such storm conditions were favorably impressed.

On the whole, oil personnel heeded the weather warnings. It was this respect for the Bureau advisories that was believed responsible for its light losses. How the industry fares in hurricanes yet to come will be interesting to note. It will largely depend on the understanding and respect given these violent disturbances — a new problem and a new challenge for the oilman.

How Hurricanes Form

Dr. Herbert Riehl
The University of Chicago
Chicago, Illinois

As oil operations grow in the offshore areas, weather becomes of added significance. A better understanding of hurricanes is important to their forecasting and to making preparations to withstand their force.

Editors Note:

Ever since the oil industry got its feet wet in the Gulf of Mexico, weather has taken on added emphasis. Hurricanes and their potential danger to offshore operations prompted the organization by the American Petroleum Institute of the API Advisory Committee on Fundamental Research on Weather Forecasting, which committee serves all branches of the industry. This committee is headed by W. J. Sweeney, Esso Research and Engineering Company, as chairman and F. L. Hartley, Union Oil Company of California, as vice chairman. Out of this committee was formed the Hurricane Panel, headed by Mercer H. Parks, Humble Oil & Refining Company, and includes R. B. Bowman, California Research Corporation, and N. D. Smith Jr., Shell Development.

As part of its continued study of hurricanes, the committee commissioned Dr. Herbert Riehl, of the University of Chicago, to prepare a "working handbook" on hurricanes. The following discussion, "How Hurricanes Form" and its counterpart, "Hurricane Motion and its Forecasting," to appear next month, were taken from Dr. Riehl's API report. The editors of *The Petroleum Engineer* are grateful to the API Advisory Committee on Fundamental Research on Weather Forecasting, to the Hurricane Panel, and to Dr. Riehl for making these pertinent facts about hurricanes available to the petroleum industry.

FORECASTING hurricane formation has been attempted only rarely. Forecasters have confined their attention to following "suspicious areas," watching closely for signs of intensification, such as organization of the winds in a circular pattern. Hurricanes develop only in areas which already contain some weather disturbance — usually marked by a weak cyclonic windfield, atmospheric pressure somewhat below average, and much cloudiness and precipitation. This one need never scan the weather map at random for signs of impending danger; the examination can always be narrowed to one or two, rarely three, areas with disturbed conditions. Such areas exist on almost every day of the season but only a minute fraction intensify — perhaps one percent. The forecaster must constantly raise the question of possible hurricane formation; the trick consists in realizing the rare combination of favorable circumstances that permits a large diffuse cloud system to organize into the spiral rainbands typical of a hurricane.

Some Ideas on Hurricane Formation

A heat release takes place in hurricanes by means of condensation of water vapor. This vapor is carried for long distance by the air currents with its "latent heat"; the heat release then takes place suddenly at a point of concentration. Proper machinery must exist to permit a fraction of the heat released to be converted into the mechanical energy of the winds.

In some ways, this machinery may be likened to a simple heat engine. As

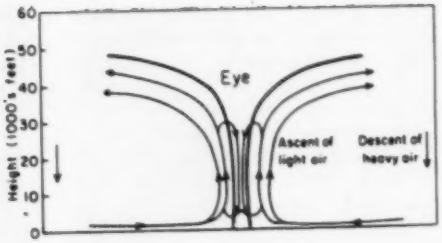


FIG. 1. **Air circulation** through a hurricane is inward and upward, as this vertical cross-section indicates. Heavy lines denote boundary of hurricane eye.

shown in Fig. 1 in vertical crossection, air ascends from a narrow ring around the eye — that area with highest wind speeds (Fig. 2 and 3). During the ascent, water vapor which is carried along condenses, liberating latent heat and decreasing the air density. In the surroundings of the cyclone, sinking motion takes place. If the density decreases due to latent heat release in the interior is large enough to lower the density below that found on the outside, then — and only then — does the circulation of Fig. 1 release potential energy and hence act to generate and maintain the energy of the winds.

An essential question now is: Do we start from an initial situation in which the moisture content, and perhaps also the temperature happen to be unusually nigh in the area with much cloudiness, or must some dynamic trigger act to establish the mass of low density in the first place so that, once called to life, the circulation may become self-driving?

Thermodynamic conditions. Hurricane formation requires the existence of an airmass with high temperature and high moisture content over a tropical ocean. Since ascent is needed for the liberation of latent heat, this airmass must possess a stratification with altitude that does not impede buoyant upward movement of air, as does a "stable" layer where the temperature increases with height (temperature inversion). Stable layers prevail over the eastern parts of the oceans in the trades, and here hurricanes do not form. Over the western parts of the oceans, i.e. in the areas where hurricanes are known to form most often, the above criteria are met on almost all days of the hurricane season. On rare occasions, now, when hurricanes do develop, air in which the circulation actually forms has about the same heat content and stratification initially as is found on the great majority of days without such a special event. Thus, the criterion states a necessary but not sufficient condition. This was recognized in the 1870's; yet the argument is still sometimes advanced as a complete explanation of hurricanes and, what is more astounding, it is put forward as a new hypothesis.

"Hot spots" on the ocean — areas with ocean surface temperature of perhaps 1 F above average — are sometimes cited as a possibility for triggering storms, since in such areas the air passing over them would acquire additional heat and moisture by transfer from the ocean surface, favoring ascent of this air. Claims of positive results have been made from time to time up to the present, always based on a small amount of evidence. Apart from quantitative demonstration, two well known facts must be overcome by the advocates of the triggering-by-especially-warm-water theory:

1. Within the broad region in which hurricanes form, there exist normal oceanic temperature contrasts; in the Atlantic region temperatures are highest in the Bahamas and in the northern Gulf. From the hypothesis, hurricane formation should be most common in those two areas; actually no such concentration exists.
2. In passing over the water, hurricanes cool the ocean surface as the latter gives up heat to the atmosphere and is stirred by the winds. When a storm becomes stationary it should weaken, following the hypothesis; just the opposite actually happens. Usually hurricanes intensify markedly when they become stagnant.

The foregoing discussion applies only to temperature anomalies of about 1 F with respect to the surroundings of the area with relatively warm or cold water. When large temperature differences are considered, such as 10 F during passage over one of the large and permanent cold ocean currents, the cold water certainly exercises a predominant influence. The air, in passing over a cold current, gives off heat to the ocean and loses its buoyancy; this readily stops not only hurricanes but tropical rains in general.

It follows that unless some new consideration, now not evident, is introduced, further research into the thermodynamic aspects of hurricane formation is not likely to prove rewarding. The thermodynamic studies have produced useful negative information, but little more. Hurricanes will not form when the air is abnormally dry and cool, or when there is present a stable layer to oppose buoyancy. When an established hurricane moves over a cold

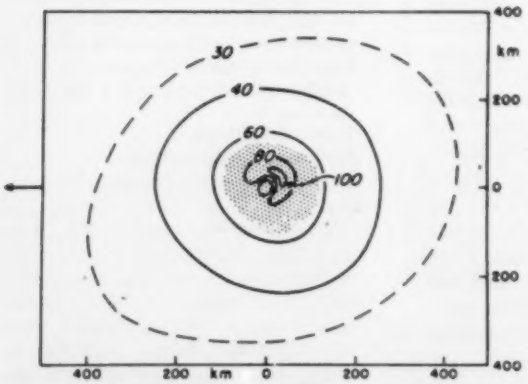


FIG. 2. **Distribution of windspeed** around the hurricane is indicated in knots. Arrow indicates direction of motion of center. Area with winds of hurricane force are shaded.

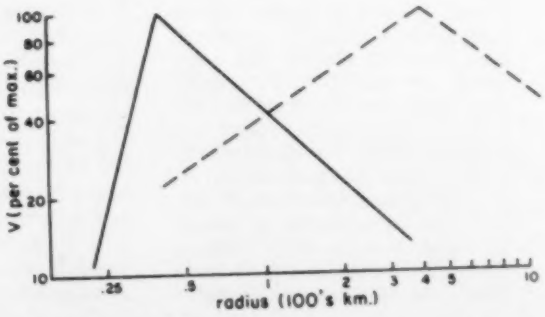


FIG. 3. **Typical distribution** of windspeed (V) in percent of maximum speed for hurricane (solid lines) and for middle latitude cyclone of hurricane strength (dashed line) as function of the radius.

ocean current — as happens off the western coast of Mexico — or when dry air enters the circulation — as happens at times when a hurricane approaches the U. S. — the hurricane will weaken, even collapse. As yet, there is little help for judging situations that are potentially hurricane forming; in all likelihood dynamic conditions provide the important criteria.

Dynamic aspects. Hurricanes form only in areas where a disturbed cyclonic windfield exists. The initial disturbance most often appears either as a wavelike undulation of the trades (Fig. 4) or as a shearline between the trades and westerlies on their equatorward side (Fig. 5). Most attention has been devoted to the second class of disturbances which for many years was likened to a front between the summer trades of the northern hemisphere, and the winter trades of the Southern Hemisphere that have crossed the equator on a clockwise curving path.

Assuming this likeness, the polar front theory of cyclone formation has been introduced into the tropics. If the air from the southern hemisphere is colder than the northern hemisphere trades, then there exists along the line where the two currents meet a temperature contrast and a marked cyclonic windshear, analogous to what is found along fronts separating air masses of polar and tropical origin in middle latitudes. If shearing waves developed along the line of wind discontinuity, they might become unstable, grow in amplitude and develop into tropical storms, just as shearing waves along fronts farther north have been thought to develop into the storms that traverse the middle and higher latitudes.

This hypothesis which held the field almost without challenge in the 1920's and 1930's has not withstood the test of time, though it is still advocated in some circles. Observations have failed to show the assumed temperature fields, and the actual evolution of hurricanes differs decidedly from the postulated one.

As upper-air soundings began to reach higher and higher altitudes during and after World War II, and as these observations became more frequent, they showed that hurricanes form largely in situations when a marked interaction between the air currents of temperate zone and tropics take place at high altitudes, between 30,000 and 50,000 ft. The atmosphere contains wavelike currents in the westerlies of middle latitudes, and in the easterly trades. Waves in the tropical easterly current travel westward, those in the middle latitude westerly current travel eastward. There is an overlap, and when waves propagating in opposite directions in the two currents meet, their amplitude increases. This amplitude increase is related to the formation of hurricanes in waves in the easterlies (Fig. 6) since it can lead to an enforced production of a large mass of air with relatively low density in the region of ascent along the wave in the tropics. Such formation, however, does not always happen so that again we have not stated sufficient conditions for hurricane development. Here the whole matter rests at present.

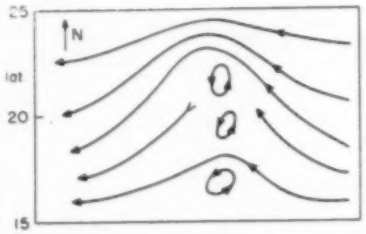


FIG. 4. **Flow in lower atmosphere** during intensification of wave in the easterlies with formation of several vortices.

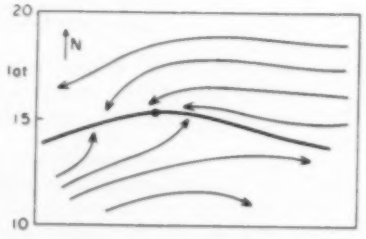


FIG. 5. **Flow in lower atmosphere** is shown here during intensification of shearline between trade winds (as illustrated by lines from the east) and equatorial westerlies.

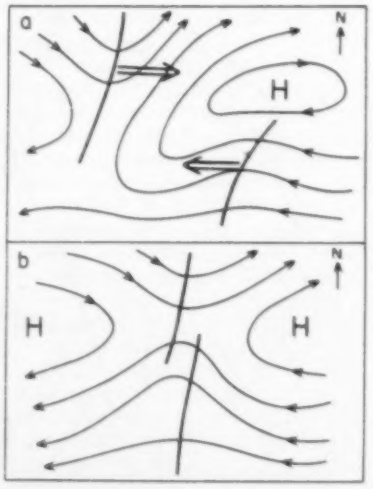


FIG. 6. **Two stages** of the disturbance, showing superposition of waves in westerlies and easterlies, with amplitude increase.

Hurricane Formation In the Gulf

When hurricanes develop in the Caribbean or farther east in the Atlantic, several days, perhaps a week, are required before they threaten some portion of the U. S. coastline. Since a one-day warning generally suffices, a forecast in Atlantic and Caribbean normally is not of practical value for protecting the U. S. coast.

This argument however does not hold when storms form in the Bahamas, since then they become a threat to the coast within one to two days. In the Gulf, almost all formations behave similarly, and both kinds of formations shown in Fig. 4 and 5 are involved. The trades emanating from the South Pacific Ocean cross the equator toward the northern hemisphere during the hurricane season. Curving clockwise, they appear in the Pacific waters off the Central American coast as a westerly current. Here they meet the Atlantic trades which have crossed Central America (Fig. 7). In the shear zone between these currents, hurricanes form with about the same frequency as in the whole Atlantic region. These hurricanes travel northwestward in the Pacific (Fig. 8). Normally they die out as they reach the cold ocean current flowing southward from California, or they strike the Mexican west coast where, because of their rain, they are likely to do more good than harm. A few of these cyclones have penetrated as far north as San Diego and Los Angeles.

Occasionally, the southern hemisphere current surges (Fig. 9); it then impinges on Central America itself, and it may appear even in the southern Gulf and Caribbean. With this shift of the shear zone, the Gulf becomes subject to hurricane formation. Incipient storms usually travel northward and affect some portion of the northern Gulf coast within two days. The September hurricane of 1956 (Flossy) was roughly of this type.

It was important for off-shore oil operations that formation of the 1956 storm be predicted and immediate warnings issued. This was difficult; even so, the situation was relatively comfortable from the meteorologists point of view compared to that which confronts him when storm formation threatens along a wave in the trade current. These waves cross from the Atlantic over Florida and Cuba into the Gulf. They usually have considerable north-south extent and reach across the entire Gulf or beyond. An amplitude increase in such cases takes

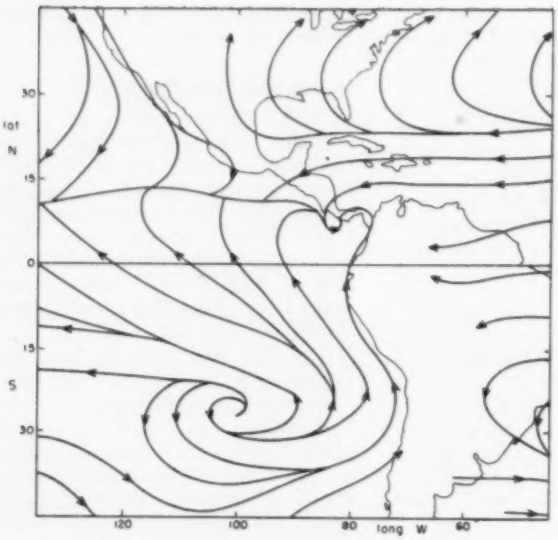


FIG. 7. **Main streamlines** follow this generalized pattern at surface in July.

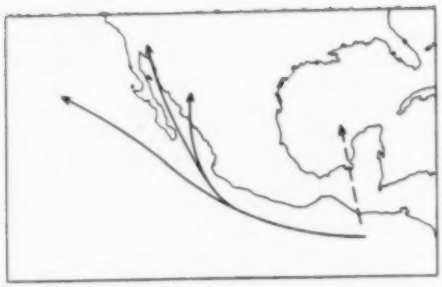


FIG. 8. **Hurricanes** in the Western Hemisphere are not limited to the Gulf of Mexico, as shown here by hurricane tracks in the Eastern Pacific and cross-over to the Gulf (dashed line).

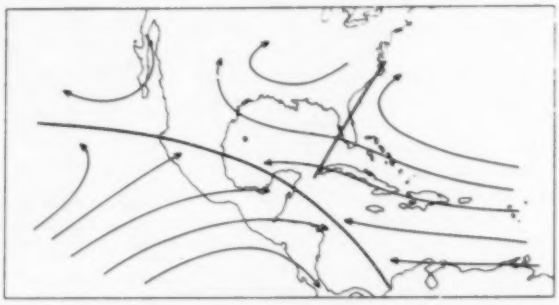


FIG. 9. **Surge of equatorial westerlies** to Gulf and Caribbean play a part in hurricane formation.

place in response to a meeting with an eastward-traveling wave in the westerlies over the U. S., and at several places along the trough in the easterlies vortices begin to form (Fig. 10).

It is far from certain that a hurricane will form; in fact, most of these situations die out after the waves in westerlies and easterlies separate again (Fig. 11). When a storm does form, the favorite place is the northernmost part of the troughline, often a short distance (say 100 miles) south of the coast (Fig. 12). Hurricane winds develop explosively within a few hours. The new cyclone, traveling northwestward to northward as a rule, will affect the coast or may even cross it in less than 24 hours. Low overcast and heavy swell will appear even sooner.

Gulf hurricanes have been very rare in recent years. But the reinforced-wave type of situation just outlined has occurred fairly often. Therefore, the forecasters have had to make a good number of critical decisions. Fortunately, the dangerous situations have passed completely or emitted only weak storms against the coast. Better tools than now exist can, quite probably, be placed at the disposal of the forecaster for judgment in these critical hours.

Long Range Studies

Little effort has been devoted to long range forecasting of hurricanes. Not that the topic has failed to fascinate the meteorological profession, but little success has yet been demonstrated in long range prediction of the general circulation in middle latitudes. This appears to be a more tractable problem than that of hurricane formation. In addition, good observations in the regions of formation have seldom existed and hurricane frequencies are open to doubt.

Sea surface temperatures. Physical approaches to long range prediction of tropical storms have been mainly concerned with sea surface temperatures and the general circulation.

Masses of water with relatively high or low temperature — one to two degrees F above or below the mean — may drift in the general direction of the ocean current in the trades which flows from east to west. Areas with anomalous temperature can be vast, encompassing, for instance, the entire Caribbean. Variations in hurricane frequency may result as the anomaly centers, traveling at a speed of approxi-

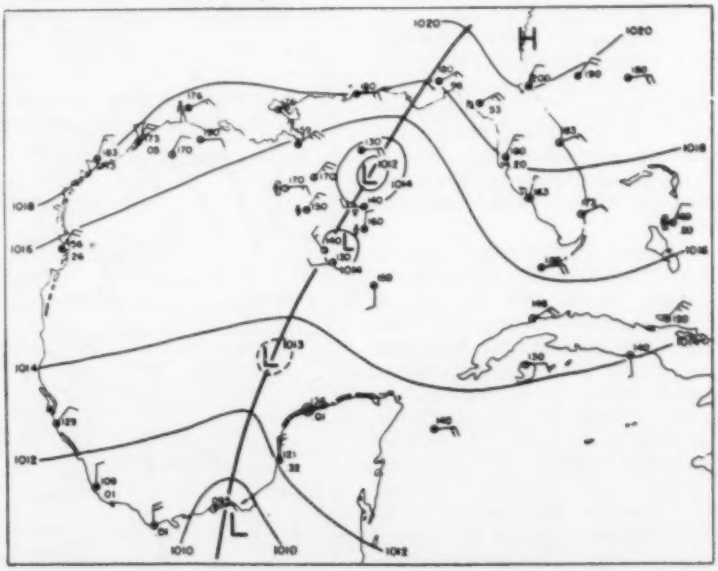


FIG. 10. **Surface chart** is dated September 10, 1941, 1930 EST. Isobars with pressure unit in millibars; L and H indicate low and high-pressure centers, solid line is troughline of wave in easterlies. International weather symbols, wind arrows show direction from which wind blows.

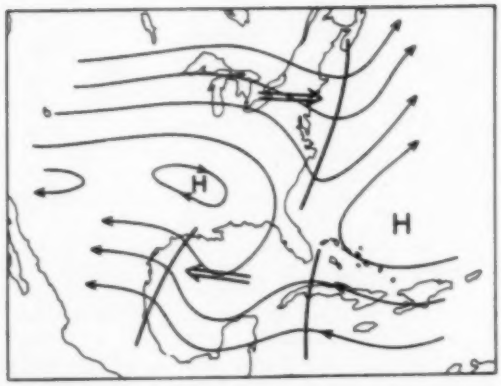


FIG. 11. **Passage of trough** in easterlies to western Gulf after intersection with wave trough in westerlies, without formation.

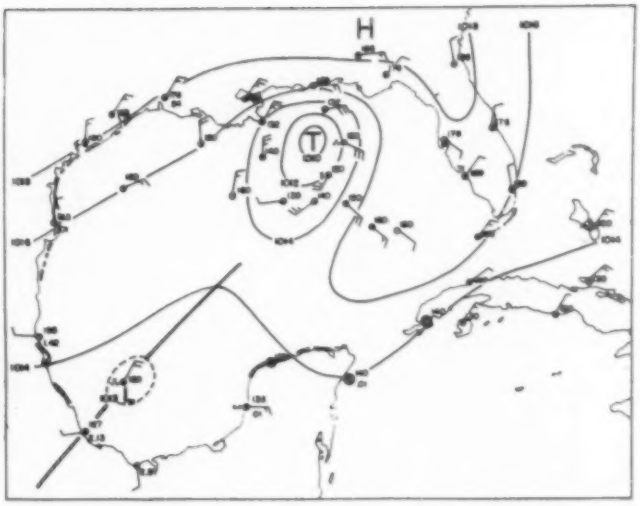


FIG. 12. **Surface chart** of September 11, 1941, 0730 EST. Notation as in Fig. 10. T denotes tropical hurricane.

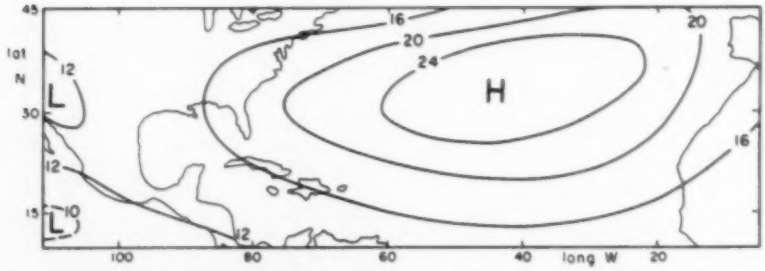


FIG. 13. **Mean surface pressure distribution** in the Atlantic, July, showing position of subtropical high. Isobars with pressure unit in millibars, first two digits omitted; for instance, 20 denotes 1020 mb.

mately 300 miles per month, arrive in or depart from the areas normally subject to hurricane formation. The variations in sea temperature may raise or inhibit and tendency toward hurricane development. This possibility has been examined with the use of sea surface temperature data available on the Atlantic from 1886-1936. For this period, the Weather Bureau prepared a tabulation, admittedly incomplete, in the 1930's. As of two years ago, this statistical work had not been extended to cover the last two decades, nor had the data missing from the previous tabulation — largely from the southeastern Atlantic — been summarized.

On the basis of this incomplete tabulation for 1887 to 1936, a correlation between monthly and seasonal hurricane frequencies and ocean temperatures was not indicated. When considering periods as long as 5 and 10 years, a correlation did appear in the sense that high temperatures and high hurricane frequencies tended to coincide, at least in the Atlantic excluding the Gulf of Mexico. The correlation, though not perfect, was nevertheless striking.

The question arises whether or not it can be used for prediction. This would necessitate long range forecasts of sea temperature, and no procedure for forecasts of this kind exists. The central problem is lack of knowledge regarding the causes of sea temperature changes. Changes in the general wind systems are the most likely cause, but this subject was not fully studied.

One possibility for using sea temperatures immediately in hurricane prediction has been pointed out. If hurricane frequencies always lagged behind sea temperatures appreciably, the lag could be exploited. Such a lag occurred once in the 1920's when sea temperatures were rising steadily, yet hurricane frequencies remaind low until 1931 when they jumped abruptly. Any explanation, on physical grounds, of this lag, followed by a sudden jump, is far from obvious. This is the only known occurrence within the span of record, and hence can hardly furnish a basis for foretelling the future. It may be added that in the Pacific Ocean, temperatures have also risen but that no significant variation in typhoon frequencies has taken place.

General circulation. The most likely determinant of hurricane frequencies is the general circulation in middle latitudes. Much qualitative and some quantitative basis exists in support of the proposition that anomalies of the general circulation and hurricane frequencies are related. Further, it is quite likely that the quantitative relations could be put on a firmer basis and extended, especially with use of upper-air data that have been accumulated.

The area of hurricane formation in the Atlantic is confined largely to the regime of easterly trade winds. Frequency of formation appears to be high when the area occupied by the trades is greater than average and when the speed of the trades is below, or at least not above, average. This is a qualitative statement, backed by general experience. Variations in the area of the trades depend on the position of the subtropical high pressure area in the ocean (Fig. 13), which separates the trades from the middle latitude westerlies. During some summers the high-pressure cell is found persistently at relatively high latitudes compared to the long period mean position of Fig. 13; during other summers it remains almost at the low latitudes where it is situated in winter.

The latitude of the high is intimately connected with the position of the main belt of westerlies in middle latitudes between 10,000 and 40,000 ft altitude. Long-range fluctuations in the latitude of this belt is precisely the parameter studied most closely and considered most important for general circulation changes. Here also lies the main connection between the general circulation and hurricane frequency forecasting. When the belt of westerlies lies farther north than average, the area of the trades will be larger than average and, by inference, the hurricane frequency will be above average — provided this hypothesized relation between hurricane frequencies and width of the trades can be proved.

Besides north-south shifts of the whole belt of westerlies, one must also consider the fact that the westerlies are a current that undulates in a wavelike manner (Fig. 6, 10 to 12). Wave troughs and ridges migrate from west to east, but there is also a tendency for stationary troughs and ridges to exist through which the moving waves pass. The quasi-stationary, or preferred trough and ridge positions, undergo marked year-to-year variations in each season of the year, including the hurricane season. This also determines in part the areas and frequencies of hurricane formation. The variations in trough and ridge positions are brought out most clearly by a chart showing the anomaly of the flow pattern of any given month from the long-period mean.

Consider a situation with wave anomaly pattern located as in September 1956, a month in which the only important hurricane formed in the Gulf (Fig. 14). The westerlies extend farthest south in the trough over the western Atlantic, as a rule the region in which most hurricanes form in September. One would expect few storms when the pattern of Fig. 14 occurs, and much evidence supports this hypothesis.

An anomaly pattern with marked westward shift of troughs and ridges occurred in 1955, a year with many hurricanes (Fig. 15). Note that the north-south amplitude of the pattern is small and that the westerlies are also situated farther north than average. Now many hurricanes should form in the western Atlantic; again the hypothesis is supported by the data. Thus, hurricane frequency appears to be a function of the latitude of the main belt of westerlies and of the location of the preferred (or standing) trough and ridge positions within this current.

Gulf of Mexico. The foregoing deductions may apply also to the Gulf of Mexico. But since this part of the hurricane belt has received far less attention in research than the Atlantic, a definite statement cannot be made at this time.

A second factor, however, may influence formations in the southern Gulf and western Caribbean. Fig. 7 and 9 have shown the flow pattern typical during hurricane formation over the southern Gulf. The strength of these equatorial westerlies, and the location of the boundary between these winds and the trades undergo marked fluctuations from year to year; perhaps there are even longer trends.

Variations in location of the boundary might be produced by changes in the flow pattern over the U. S. One cannot exclude, however, the possibility of an influence across the equator. The principal subtropical anticyclone in the South Pacific lies due south of the Gulf (Fig. 7). This is related to the general eastward slant of the western coast of the Americas from north to south. During the Gulf hurricane season it is winter in the southern hemisphere; possibly the South Pacific high and the South Pacific westerlies undergo marked changes from one year to the next, just as discussed above for the northern hemisphere westerlies. If true, the equatorward outflow from the anticyclone will be large or small depending on position and intensity of this "center of action."

The boundary between the outflowing current and the northern trades will also fluctuate. When the boundary is displaced toward a more northerly position than average, the wind shear across it will be sharper than normal and a relatively large number of tropical cyclones will form. Hence we may be dealing with a double effect. More storms may form in years with a strong South Pacific high, and since the area of formation is farther north than average, a greater number of the incipient storms may be channelled into the Gulf rather than remain in the Pacific to travel along the western coast of Central America. ★ ★ ★

The second and last part, *Hurricane Motion and Its Forecasting* will appear next month.

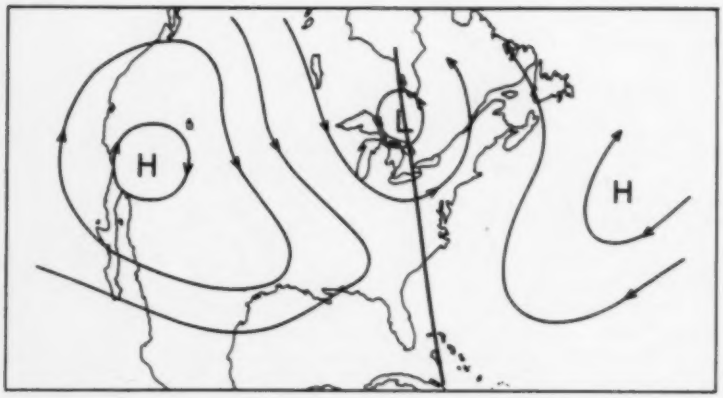


FIG. 14. **Deviation of circulation** at 10,000 ft altitude from monthly mean, September 1956.

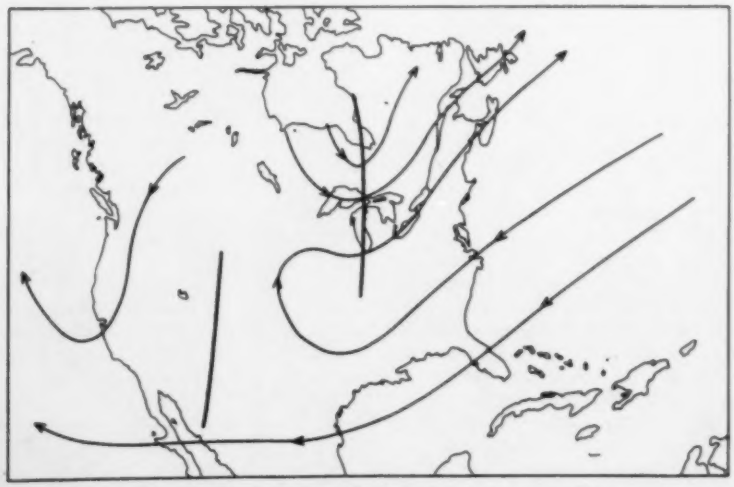


FIG. 15. **Deviation of circulation** at 10,000 ft altitude from monthly mean, September 1955.

Drilling fluids, perforating, well clean-up, cementing and sand control methods do affect future well performance . . . but fracturing, acidizing and surfactant treatments can remedy detrimental effects.

EFFECT OF DRILLING AND COMPLETION METHODS ON

Producing Well Performance

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IN general, the owner of a producing well is interested in its performance insofar as such performance affects: (1) The amount of ultimate recovery of oil and gas from the well; (2) the rate at which the oil and gas reserves can be recovered, and (3) the cost of recovering the oil and gas reserves.

Consequently, the well owner usually desires to complete his well so that it will perform as follows:

1. Yield maximum hydrocarbon recovery in terms of percentage of materials in place. This usually requires exposure of all parts of a reservoir to drainage and requires choice of completion interval in such a way as to result in minimum gas and water production per barrel of oil.

2. Yield the hydrocarbon fluids at a rate at least as high as natural conditions permit. This requirement dictates that there be no avoidable restriction at or near the wellbore that will hinder entry of hydrocarbon fluids.

3. Permit recovery of the hydrocarbon fluids at a minimum cost in terms of dollars per barrel or Mcf. This requirement dictates minimum water production, a maximum period of natural flow and also necessitates exclusion of sand.

There are various features of the drilling and completion process to be considered that have a significant bearing upon whether a well performs in such a way as to accomplish these three objectives.

Paper presented at study group meeting of Dallas Section of Society of Petroleum Engineers of AIME, February 14, 1957.

Methods of Measuring Drilling and Completion Effects

Wade[1] used a factor, "production effectiveness" as a basis for comparing the effect of various features of completion on well productivity. He defined production effectiveness as the ratio of the absolute reservoir permeability as calculated from flow tests to the average air permeability as determined by core analysis. Thus, a lower production effectiveness would represent a greater degree of damage.

Results of bottom-hole pressure build-up tests can be used for determining completion effectiveness as previously discussed by Arps.[2] This entails the use of a yardstick called "completion factor," which is defined as the percentage of the theoretically possible productivity which has been obtained in completing the well or, in other words, it is the ratio of actual productivity to theoretical productivity expressed in percent.

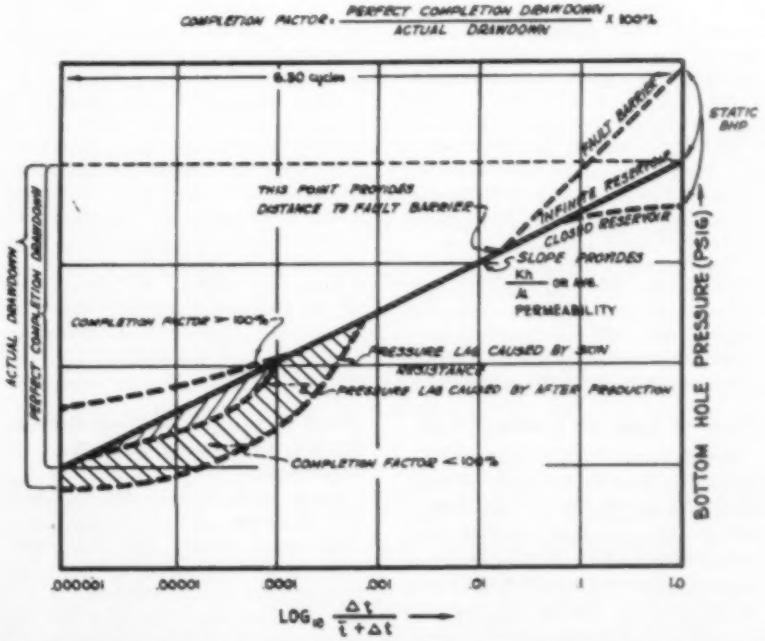


FIG. 1. **Application of bottom-hole pressure build-up.** The solid straight line represents pressure increase relationship of a clean well that has been on steady state production and is then closed in for pressure build-up. This illustration is after J. J. Arps, Reference 2.

In a well that has not been artificially stimulated by fracture treatment or acidization, the completion factor should always be below 100 percent. Oftentimes, a fractured well or an acidized well may show a completion factor greater than 100 percent, which merely means that the effective permeability of the zone near the well is greater than that of the outlying formation in its natural state.

The completion factor, already defined as the ratio of the actual productivity to theoretical productivity, may also be represented by the ratio of theoretical pressure draw-down to actual pressure draw-down, expressed as a percent.

A perfectly clean well that has been on steady state production and is then closed in for build-up of pressure should yield a pressure increase relationship as represented by the solid straight line of Fig. 1. Actually, however, when a well is closed in at the surface, the formation continues to produce some fluids for fill-up of the wellbore and this will usually cause some lag in the rate of pressure build-up as represented by the dotted curve line just below the solid line on the left-hand side of Fig. 1. If there is skin effect or completion damage near the wellbore, there will be additional lag in the early part of the build-up and the curve will take a path of the type represented by the lower dotted line, and the well will yield a completion factor less than 100 percent.

If the well is artifically stimulated by means of fracture treatment, acidization or any similar process that would increase the flow capacity of the zone near the well above that existing in the zone away from the well, the early part of the build-up will be more nearly according to the upper dotted line.

This last condition would result in an actual draw-down less than that theoretically expected and, therefore, the completion factor would be greater than 100 percent.

Comparison of completion factors, as determined from pressure build-up curves, is the most satisfactory method yet developed for measuring the relative effects of various drilling and completion methods on well performance.

Effect of Type of Drilling Fluid

In the conventional process of drilling the pay zone by the rotary method, the pressure exerted by the drilling fluid column exceeds the reservoir pressure and this condition usually leads to entry of some of the drilling fluid or a filtrate from the drilling fluid into the formation. In the usual case when drilling zones in which the pore space is of the intergranular type, penetration of the pay zone is primarily by the liquid phase of the drilling fluid to the exclusion of the solid phase of the drilling fluid. Normally, the solids are stopped as a filtercake on the wall of the bore hole while the penetrating filtrate may enter several feet into the pay zone.

Certain test data indicate, however, that even in intergranular zones, there is some penetration of solids into the matrix. Fortunately, the effect of these solids can be overcome by penetration with bullets or jets in a later perforating process using a clean fluid that does not contain such solids.

If the formation is of high enough permeability to permit bodily entry of mud, including its solids, the detrimental effect to the pay zone is not necessarily permanent since it can be removed by clean-up methods such as bailing, swabbing, or even pumping. The effect of water filtrate from conventional drilling mud usually is more permanent and more difficult to remedy than the effect of filtercake or slight penetration of the zone by solids. The forces of capillarity favor the retention of this water by the sand pores. This is true because the sand attracts water with a greater capillary force than it attracts oil and, thus, it is difficult for oil flow to remove this infiltrated water. Removal of this filtrate can be aided by injection of surface tension reducers or surfactants, that are sold under various trade names.

In general, oil-base fluids are less damaging to pay zones than water-base fluids. This is easily explained by the fact that the filtrate is oil rather than water and the oil is not preferentially retained by the sand when the well is placed on production.

Wade[1] compared the production effectiveness for wells drilled with water-base, oil-base and special water-base muds. He found that the mean production effectiveness for 40 wells drilled with water-base mud was .11. In the same fields using oil-base mud on 43 wells, the mean production effectiveness was .165 or, in other words, on the average the wells drilled with oil-base mud showed 50 percent higher production effectiveness than the wells that were drilled with water-base mud.

Effect of Length of Time Drilling Fluid is in Contact with the Pay Section

Wade[1] included a statistical analysis to determine the mean production effectiveness of two groups of wells. One group being those in which the drilling fluid was exposed to the pay zone a relatively short time and the other group representing those in which the drilling fluid was in contact with the pay zone a significantly longer time.

Using oil-base mud, one group of wells was drilled-in in less than 15 days and showed a mean production effectiveness of .19 which was 52 percent higher than the mean production effectiveness of .125 indicated for another group of wells that required over 15 days for drilling. His data for similar groups of wells with water-base mud showed the same general trend. Wells in which the pay zone was drilled in less than 15 days showed approximately 50 percent higher mean production effectiveness than those that required more than 15 days for the drilling-in process.

Effect of Cementing Practices

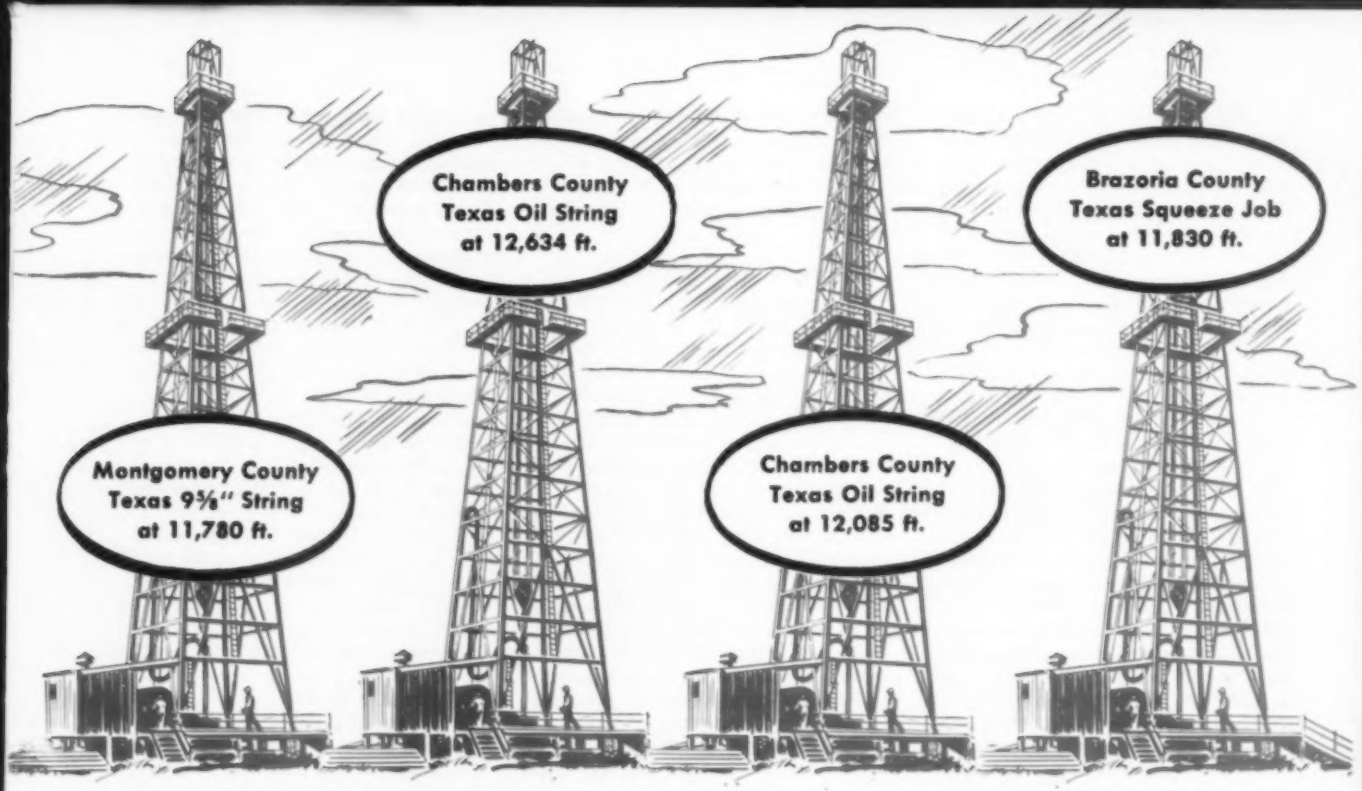
There is a general feeling among completion engineers that cement may have a detrimental plugging effect on low-pressure zones, particularly those that have cavernous or vugular porosity. Actually, there seems to be little reason for concern if dealing with intergranular type porosity because penetration of cement into such a zone is so slight that perforation or fracture treatment penetrates any cement plug or sheath and eliminates its effect insofar as completion damage is concerned. There is more reason for concern with cementing practices in wells where the pipe is set through the pay zone. In these wells, the main objective is to secure a good seal behind the pipe which will remain a good seal after perforating the pay interval. By maintaining such a seal, even after perforation, the operator is able to exercise the selectivity that is required to prevent channeling of water or gas and, thus, be permitted to produce the oil most efficiently.

No exact numerical criteria have been devised to demonstrate the effect of cementing practices on well performance, but in order to secure the proper seal to permit selective production of oil with minimum water and gas, the proper use of scratchers and centralizers in gage hole seems to be the most important feature of the completion plans.

Open Hole vs Perforated Completions

There has been a long standing question in the minds of production men regarding the relative performance of a well completed with pipe set through and perforated as compared to a well where pipe is set on top of the pay zone and the production obtained through open hole.

Theoretical analysis by a mathematical approach considering spherical flow to the base of each perforation and essentially neglecting any fracturing that may have been caused by the perforating process, indicates that in a gas



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field the productivity of a well perforated with eight holes per foot would be 66 percent of the productivity of the same well if completed with open hole. Using 16 holes per ft, the productivity of a perforated well would be only 82 percent of the productivity to be expected with open hole. This approach is theoretical and disregards the effect of the fracturing that occurs adjacent to any perforation produced by a bullet or jet. Therefore, the reduction in productivity indicated by this mathematical approach is more severe than is ever actually experienced in a properly executed well-perforating job.

In the West Edmond (Oklahoma) field, a statistical comparison was made of a large number of wells that were completed with open hole as compared to another large number that were completed with perforations.[3] There were more than 100 wells in each category. There was no recognizable difference in the initial productivity and performance of these two groups of wells. Therefore, this comparison indicated that either method of completion could be so handled as to complete a good clean well with little damage.

In general, the perforated completion is favored because of its selectivity feature but, often times, the open-hole method is favored in certain consolidated low-pressure zones, especially if the reservoir is cavernous or vugular so as to permit bodily entry of cement into the pay zone for an extended distance.

Effect of Perforating Method

Allen and Worzel[4] presented the results of productivity tests made on Berea Sand cores under various simulated conditions. From this study, they concluded that the worst possible perforating conditions for obtaining adequate productivity are:

1. Perforating with charges which produce perforation-plugging carrots.
2. Perforating in heavy mud.
3. Perforating with a high differential pressure into the formation.

They also expressed doubt that adequate penetration was obtained with bullets when using higher strength of casing and fully set cement in hard formation.

The perforating process may cause considerable fracturing of the cement sheath behind the casing. In general, this is believed to be less damaging when using jets than when using bullets. It may be also minimized by perforating the cement when it is somewhat green. At least, this is an important feature when perforating close to a gas-oil or water-oil contact, since the performance of the well as to gas-oil ratio and water-oil ratio may be significantly affected by this fracturing.

Well Clean-up

In the Steamboat Butte field of Wyoming, some of the earlier wells were completed by either drilling in with mud as an open-hole completion or perforating with mud and merely circulating the mud out of the hole and placing the well on production without any period of clean-up by means of bailing or swabbing.

Pressure build-up tests on these wells showed very little difference between open-hole and perforated completions but indicated a completion factor between 50 and 70 percent for various individual wells. Later, on other new wells, a deliberate effort was made to thoroughly clean the well by means of bailing and swabbing before placing it on normal production.

With clean-out periods ranging from 5 to 12 days, pressure build-up tests later showed that the wells were in good condition since the completion factor was approximately 100 percent.

Fracture treatment, acidizing, and surfactant treatments are forms of well clean-up, although the first two processes may be used for artificial stimulation of wells that even in their natural state would not have adequate productivity. In other words, completion damage can be remedied in many cases by use of the fracturing process, acidizing or surfactant treatment.

Control of Sand Production

In many of the unconsolidated sand reservoirs of the Gulf Coast area, a well must be so completed as to permit proper control of the sand in order to prevent excessive equipment wear and trouble during the productive life of a well. In many cases, this condition has practically eliminated the use of dual completion as a means of depleting these unconsolidated sand reservoirs, because of the difficulties with erosion of tubing in the upper zone of a dual completion and ultimate sticking of the tubing due to entry of sand from the upper zone.

Control of sand consists of (1) pressure gravel-pack, or (2) sand-lock which involves placement of walnut hulls and plastic so as to form a network to permit entry of fluid and yet hold back the sand.

Overall Completion Design for Maximum Future Control

There are certain features of the completion plans that may have little effect on the initial performance of the well but have a great bearing on the ease with which the well may be controlled at some later date when conditions have changed. This is illustrated by the necessity of wise choice of perforated interval to permit future control of gas-oil ratios or water production when the gas-oil or oil-water contact has moved to some new level as a result of production.

In this connection, hole size is important. In one field, in the original completion of earlier wells a full-sized hole was drilled through the pay zone before setting casing. Casing was then set with a pack-off shoe at the top of the pay zone. This left the pay exposed in a hole of diameter some 4 in. greater than the inside diameter of the casing. This is a thick section in a reservoir with an active water drive. It is difficult to use a packer to selectively test for points of water entry in a 9-in. hole when the packer must be run through 5½-in. casing. It is also impossible to set, cement, and perforate a liner because of the small diameter of the production string.

The mechanical problems attendant to workover for water exclusion would be considerably simpler in this field if the open hole were of no greater diameter than that of the inside of the production casing. This point is merely illustrative, and there are several other features of completion methods that should be included in the plans so as to simplify future problems even though they do not immediately affect well performance.

Conclusion

Summarizing, there are several features of the completion process that affect future well performance. These features include type of drilling fluid, length of exposure of drilling fluid to pay section, perforating methods, well clean-up methods, cementing methods, and sand control.

Even though the performance of the well may be significantly affected by one or more of these features, the detrimental effect may often be remedied by use of certain stimulative measures, such as fracturing, acidizing, and surfactant treatment.

It is particularly important to design a completion for the entire productive life of the well, rather than just for initial well performance.

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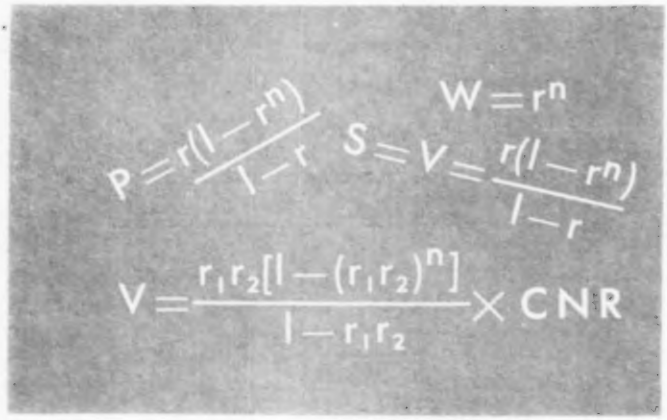
For preliminary examination, check on formal appraisal, here's a . . .



Short Cut Valuation Of Producing Properties

To buy, sell, or trade oil producing properties, here's a quick and reasonably accurate way to determine values

C. A. Awalt
Petroleum Consultant, Fort Worth, Texas

To make preliminary examinations, check results of formal appraisals or possibly to form the basis of royalty transactions, a short-cut valuation method has been developed. When used with care, this simplified approach can be of considerable aid in the quick estimation of oil and gas producing property values.

A producing oil or gas property has value because it pays revenue over and above expenses. The appraisal of that value is closely related to the purpose for which the appraisal is to be used, and possibly in most cases that purpose is involved with a prospective change in the ownership of the property. There are a number of recognized methods of determining market value, and the engineering type of appraisal gives the most reliable result. However, it is not always possible to secure this type of appraisal; indeed, it is sometimes not even necessary. Lack of time may demand a short cut, or ideal producing conditions may render a short cut more desirable in the interest of economy.

The determination of market value is basically the determination of the total future net revenue, the time within which it can be realized and the discount applicable due to the time element. In every transaction, the prospective buyer of a producing oil or gas interest must decide whether the price asked is within reason, that is to say, whether the investment will return a profit attractive enough to justify the risk. The decision often hinges on a consideration of the payout time in relation to the future life of the property. By payout time is meant the number of months or years required at the current rate of return to repay the purchase price.

Discount tables reveal the relationship of payout time to future life in terms of interest yield per period. For example, if a property is producing $50 per month net revenue, and is offered for $5000, the payout, of course, is 100 months. Whether or not this would be a good investment depends on the future life of the property, and the likelihood of the producing rate holding steady or declining. The buyer, either from his own knowledge, or from that gained from an engineering study of the property ascertains what the future life in terms of interest yield per period. For profit yield per period.

If a series of payments of $1 per year is to be received over n years, and d is the discount rate, the worth of any payment of the series is $W = \frac{1}{(1+d)^n}$, and if $r = \frac{1}{1+d}$, $W = r^n$

The payments thus discounted from a geometric series, the summation of which to n terms (from any standard text) is

$$S = \frac{a(r^n - 1)}{r - 1} = \frac{a(1 - r^n)}{1 - r}$$

Since a is the first term of the series, it is equal to r (that is, the first dollar due one year hence) consequently the worth of the entire series is

$$S = V = \frac{r(1 - r^n)}{1 - r}$$

Likewise, the rate of oil or gas production which undergoes "constant percentage decline" per period forms a geometric series, and can be treated by the same formulas.

Constant production decline.

Consider a property whose producing rate is undergoing constant percentage decline, or to state it another way, whose producing rate continues at a constant percentage where each period's production is some constant percentage of the previous period. The future production to n years, in terms of the current rate (that is, the immediate past period), is $P = \frac{r(1 - r^n)}{1 - r}$. Thus, a lease producing at 100 bbl per day, averaged over the last year, whose producing rate is con-

tinuing at 80 percent per year, will produce in the next 10 years,

$$P = \frac{.80(1 - .80^{10})}{1 - .80} \times 100 \times 365 = 130{,}378 \text{ bbl.}$$

At the midpoint (approximately) of the tenth year, the producing rate will have diminished to 10.7 bbl per day ($100 \times .80^{10}$).

It is apparent from the above that the expression r^n represents the ratio of the final rate to the current rate, the final rate being the economic limit. Suppose, for example, the economic limit is assumed to be two barrels per day. Then, $r_n = .80^n = \frac{2}{100} = .02$. Whence n = 17.5 years, and the future production will be,

$$P = \frac{.80\ (1 - .02)}{1 - .80} \times$$

$$100 \times 365 = 3.920 \times 36500 = 143{,}080 \text{ bbl.}$$

Suppose an investor wants to make an offer to purchase this property (which, let us say, is a royalty interest) and wishes a profit of 10 percent per year on the investment. What price should he pay to yield this return? This could be determined by scheduling the future net revenue by years on a continuance rate of 80 percent per year for 17.5 years then multiplying each by the proper discount factor and adding for a total. But, the same answer can be gained precisely by combining the two rates into one and solving the equation,

$$V = \frac{r_1 r_2 [1 - (r_1 r_2)^{17.5}]}{1 - r_1 r_2} \times \text{Current Net Revenue}$$

$$r_1 = .80,\ r_2 = \frac{1}{1 + .10} = .9091$$

$$r_1 r_2 = .72728$$

$$V = \frac{.72728\ (1 - .72728^{17.5})}{1 - .72728} \times \text{CNR} = 2.657 \text{ CNR.}$$

Combination rates. Consider another example of royalty interest, and assume a property will produce at a constant rate for five years at 70 bbl per day, then at a continuance rate of 87.5 percent per year to an economic limit of 3.5 bbl per day. Production for the first five years will be,

$$P_1 = 70 \times 365 \times 5 = 127{,}750 \text{ bbl}$$

and production from the fifth year to the economic limit will be,

$$P_2 = \frac{.875\left(1 - \frac{3.5}{70}\right)}{1 - .875} \times$$

$$70 \times 365 = 6.650 \times 25{,}550 = 169{,}908 \text{ bbl}$$

$$P_1 + P_2 = 297{,}658 \text{ bbl}$$

And since $.875^n = \frac{3.5}{70}$,

$$n = 22.5 \text{ years}$$

What is this production worth to an investor who wants a a profit of 12.5 percent per year on investment? The first five years net revenue is worth,

$$V_1 = \frac{r_1\ (1 - r_1^5)}{1 - r_1} \times \text{CNR. And}$$

$$\text{since } r_1 = \frac{1}{1 + .125} = .8889,$$

$$V_1 = \frac{.8889\ (1 - .8889^5)}{1 - .8889} \times \text{CNR} = 3.560 \text{ CNR}$$

Definition of Terms

V = Value or cost when expressed in dollars, or payout when expressed in time
d = Discount rate
n = Number of periods
$r = \frac{1}{1 + d}$ = Continuance rate
S = Summation
W = Present worth
P = Future production, barrels
CNR = Current net revenue, or the net revenue received over the immediate past period.

The net revenue from the fifth year to the economic limit is worth,

$$V_2 = r_1^5 \frac{r_1 r_2 [(1 - (r_1 r_2)^{22.5}]}{1 - r_1 r_2} \times \text{CNR}$$

$$r_1 = .8889,\ r_2 = .875,\ r_1 r_2 = .7778$$

$$V_2 = .8889^5 \frac{.7778(1 - .7778^{22.5})}{1 - .7778} \times$$

$$\text{CNR} = .555 \times 3.488 \text{ CNR} = 1.936 \text{ CNR}$$

$$V_1 + V_2 = 5.496 \text{ CNR}$$

That is to say, the cost or value of this property to yield a return of 12.5 percent per year on money invested is 5.496 years of net current revenue.

How much profit? A natural question arises: What would the total profit be? The answer lies in the fact that the total net revenue from the property would be 11.650 years of current net revenue, for which had been paid 5.496 years, giving an overall profit of 112 percent. The cost would have been recovered in about six years, leaving the balance as profit.

How much tax? The next question might be: Where will the purchaser be after paying his income tax? This discussion cannot become too involved in the intricacies of the income tax field, but let it be recognized at once that the purchaser will suffer no loss on the investment by reason of the payment of income tax, regardless of his tax bracket.

Unfortunately, the tax must be paid, and after payment there will be less net profit remaining, but there will be some, because the tax is required to be paid on profit only and not on the return of capital. Assuming for the purchaser a 40 percent tax bracket, for instance, the tax reckoned on cost depletion would be approximately $.40\left(1 - \frac{5.496}{11.650}\right)$ or about 21 percent of every dollar of net revenue.

Accuracy of method. The use of this method applied to royalty interest will give precise results in cases where the continuance rate is a constant percentage per period, or to state it in its usual form, where the decline in producing rate is a constant percentage. In cases where the decline departs from a constant percentage, approximations are obtained which may be close enough to satisfy most requirements.

The Author

C. A. Awalt is on the engineering staff of Pritchard and Abbott, valuation engineering firm of Fort Worth, Texas, where he has been doing valuation work since 1949. He also is engaged in limited private consulting work. Prior to 1949 he spent some 15 years with a major oil company in various engineering capacities. He is a registered professional engineer, and a member of the Society of Petroleum Engineers of AIME.

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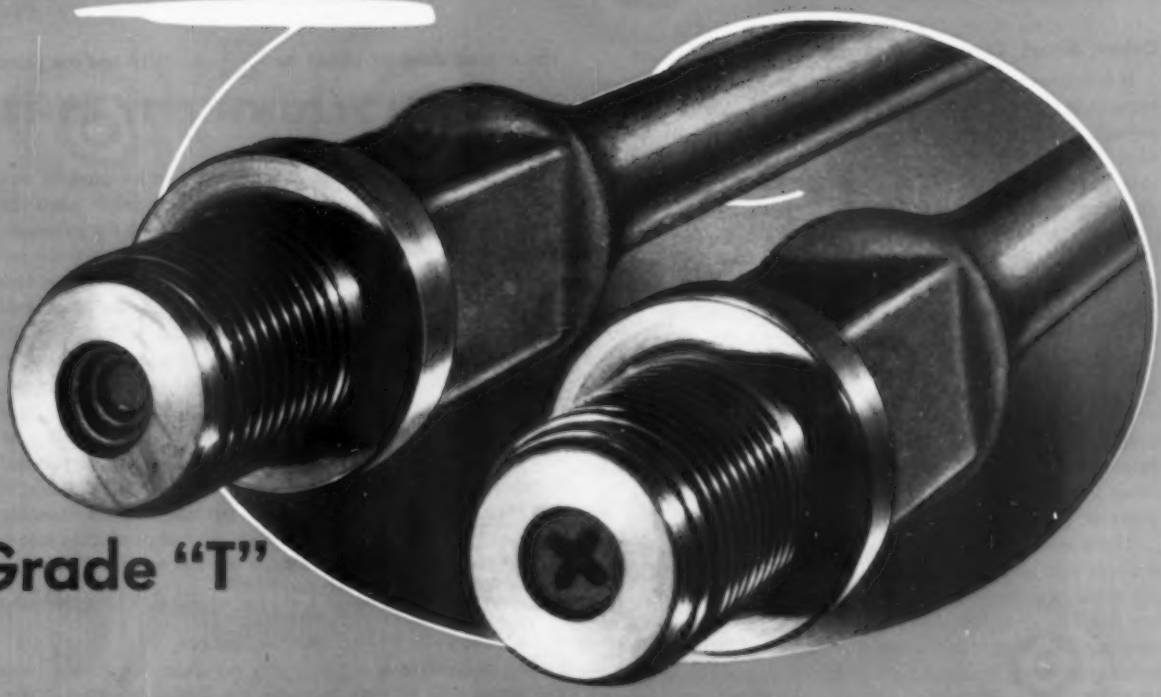

Grade "T"

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A MAJOR CAUSE of sucker rod failure in hydrogen sulfide (sour corrosion) wells is the embrittlement of the rod caused by the corrosive environment. "Oilwell" metallurgists have uncovered or confirmed several principles that have guided us in designing "Oilwell" Sucker Rods "T" and "W." As a result, these rods have, for many years, given outstanding service in sour wells.

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Grade "T" is a medium-strength rod designed for pumping to intermediate depths, and Grade "W" is a high-strength rod for use in deep wells.

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In the case of working interest, the use of this method yields satisfactory results when total future operating costs are expressed as a per barrel average. Where production may be expected to hold steady throughout most of the remaining life, results within two or three percent of that obtained by a more elaborate treatment may be expected. Where production is expected to decline, the range of accuracy may be reduced to around 90 percent.

Other Short Cuts Compared

It is interesting to compare some other short cuts that have been used in the past by operators as a trading basis, such as payout, price per barrel of daily average production and the like. The payout related to future life at different discount rates reveals the quality of the investment in terms of profit yield per period.

The price per barrel of daily average production is basically the payout expressed another way. For instance, if property sold on the basis of $1000 per daily average bbl, when oil was bringing $1 per bbl, it meant the gross payout was a little over three years. If expenses were 25 cents per bbl and royalty was ⅛, the operator's net was 62.5 cents per bbl or $228 per bbl per year, which would be a net payout of about 4⅓ years. This yardstick was used extensively where production performance showed much uniformity and could be depended on to yield the purchaser an overall return of something like 2:1 or 2½:1 over an extended life of about 20 years or about 10 years at the current rate.

There is another yardstick which is still used by some appraisers and accepted by lending institutions. It is based on the value of a barrel of oil in the ground. In general, this figure is taken at $1 per bbl and applied to the calculated remaining reserve without much regard to the relationship between producing rate and remaining life. It must be admitted that this gage is as sound as price per bbl of daily average production, although neither can be defended as basically sound for universal use. The chief difference between the two is that the price per barrel of daily average production was employed for areas where production performance was notably uniform, and the figure of $1000 per bbl probably came out as a result of a serious analysis of the production performance and the expenses to be encountered, while the gage of $1 per bbl in the ground might have resulted from an equally competent analysis of conditions on a lease or within an area, but its application did not stay put, and came to be used somewhat indiscriminately.

Fallacy of the indiscriminate use of this measure of value may be illustrated by two examples. Consider two properties, each producing 50 bbl per day net after royalty, expenses at 50 cents per bbl, and crude price at $3. The net revenue from each is $2.50 for each bbl produced. Assume property "A" to have net reserve of 100,000 bbl, and the current rate to remain constant. Its life would be 5.48 years. It is doubtful that the present owner would sell the property at a figure that would permit the purchaser to realize a profit of 20 percent per year, but let's assume this to be the case. The payout then would be:

$$V = \frac{.833\ (1 - .833^{5.48})}{1 - .833} = 3.160 \text{ years.}$$

The overall discount would be $\frac{3.155}{5.48} = .5766$ and the price per barrel in the ground in this instance would be $2.50 \times .5766 = \$1.44$.

Assume property "B" to have a net reverse of 1,000,000 bbl. The life of this property at 50 bbl per day, constant rate, would be 54.8 years. Let us assume that this property changed hands on the basis of 10 percent per year discount. The payout would be:

$$V = \frac{.9091\ (1 - .9091^{54.8})}{1 - .9091} = 9.95 \text{ years.}$$

The overall discount would be $\frac{9.95}{54.8} = .1816$ and the price per barrel in the ground in this instance would be $2.50 \times .1816 = \$0.45$.

Choice of periods. This formula can be adapted to any periods, and may yield a little more accurate result when the periods are expressed in months to coincide with the payments from runs. However, this substitution in the research for accuracy would hardly be consistent with the assumption of factors not subject to accurate determination. Choice of periods would perhaps best be predicated on the wishes or convenience of the user. Whatever the period selected, the corresponding rates can be found from the basic rate. For example, an annual continuance rate of 80 percent is equivalent to a monthly rate of $.80^{1/12}$ or .9816. The end result in either case will be very nearly the same if the current rate is considered to be in effect at the midpoint of the current period. Thus, if the annual continuance rate is 88 percent and the monthly rate is $.88^{1/12}$ or .9894, and the current annual producing rate is 10,000 bbl, the producing rate for the last month of the current year would not be $\frac{10,000}{12}$, but would be $833 \times .9894^{5.5}$ (very closely) $= 833 \times .9430 = 786$ bbl.

This procedure is not precisely accurate, but results from the summation of both formulas are within less than 1 percent and are probably closer to accuracy than the results obtainable by extrapolating the two curves from their graphs. By way of comparison:

Using the annual rate for 10 years,

$$P_y = \frac{.88\ (1 - .88^{10})}{1 - .88} \times 10,000 = 52,950 \text{ bbl}$$

Using the monthly rate for 120 months,

$$P_m = \frac{.9894\ (1 - 9894^{120})}{1 - .9894} \times 786 = 52,969 \text{ bbl.}$$

Uses for method. In any sort of oil and gas appraisal, the appraiser generally projects into the future the conditions presently existing, such as price of crude oil and gas, allowables and such. Naturally, there are other conditions affecting the transaction, directly and indirectly. Of the latter, the general health of the economy, the overall picture as to allowables and imports, stability of crude prices and the like, none of which can be measured, but all of which will have some weight in the minds of the buyer and seller. Consequently a thorough analysis will present the principal with the best information to assist him in arriving at a decision.

The short cut appraisal should be used with the greatest of care. It may prove of much service in a preliminary examination, or as a check on the result of the formal appraisal, or possibly as the basis of a royalty transaction in a unitized or settled area. ★ ★ ★

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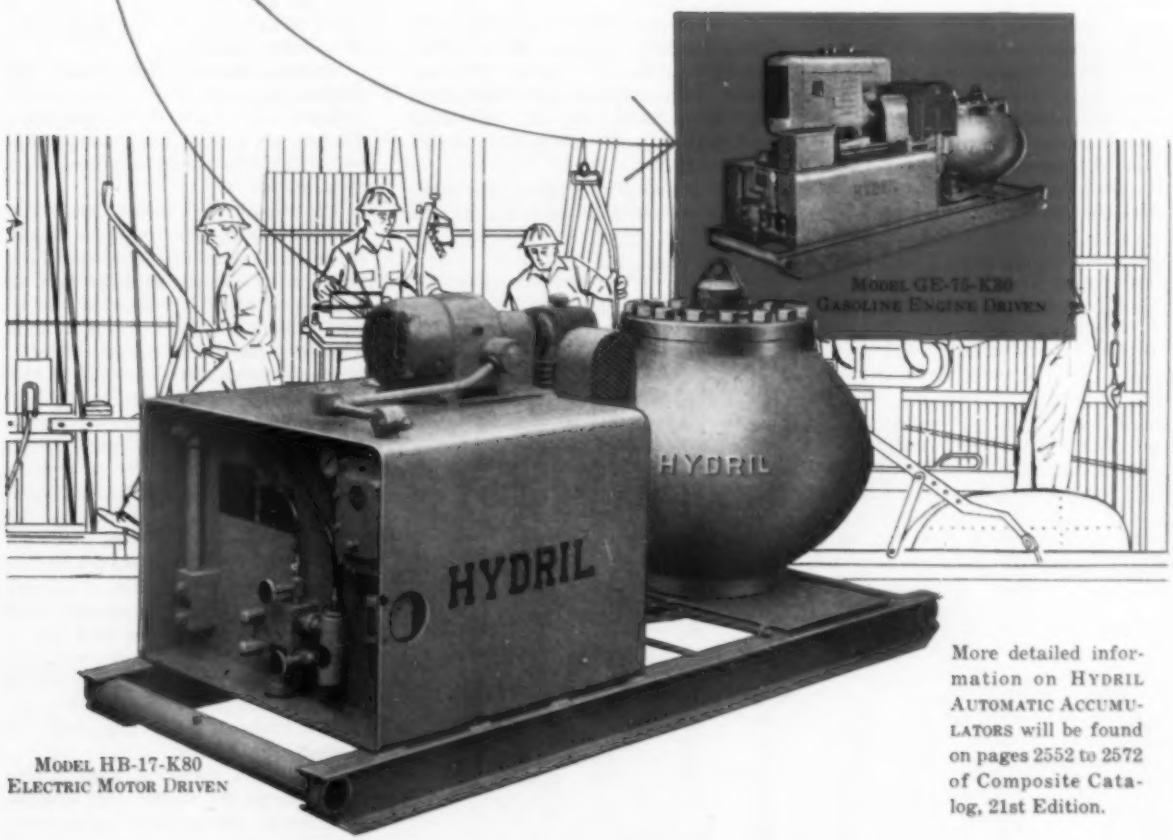

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AAODC takes a stand against excessive oil imports.

Oil Imports vs The Drilling Contractor

Jack H. Abernathy, president of the American Association of Oilwell Drilling Contractors recently presented the following statement to the Office of Defense Mobilization in a plea to trim oil imports. His remarks were addressed to Gordon Gray, director of the Office of Defense Mobilization.

ONLY the drilling bit finds oil.

The impact of imports on the domestic oil well drilling industry is thus one of the chief factors which should be taken into account when you consider possible courses of action in the imports situation.

The American Association of Oilwell Drilling Contractors, of which I am currently president, includes more than 650 members who drill about 75 percent of all footage in the United States and operate a considerable number of rigs in foreign countries.

We drill oil and gas wells on a contract basis for domestic affiliates of the great importing companies, for major integrated domestic organizations, and for independents of all sizes from the largest to the smallest. We are therefore forced by circumstances into a middle position — one which is not too far, it seems to me, from the position our Government should occupy.

On October 22, 1956, I presented, at a hearing conducted by your office, an outline of our views and the reasons therefor in some detail. I respectfully urge that you read it at your early convenience.

My recommendation was that your office take appropriate steps to reduce imports to the 1954 ratio. I believe events since that time add emphasis to my recommendation, and this letter will explain some reasons I think this to be a fact.

The attached table shows the number of rotary rigs operating in the United States during the past several years. The marked reduction in rig activity since December 1955 is evident —the drop being 608 rigs in 14 months (754 since peak).

Over the years, more than 70,000 bbl of oil have been found per hole drilled in this country.

The average rotary rig operating steadily drills about 19.5 holes annually, thus about 1,370,000 bbl of crude oil are added to our nation's reserves per rig per year.

Put another way, 730 rotary rigs running find *one billion barrels* of crude oil annually, plus a great quantity of valuable natural gas.

Simple arithmetic shows that if the present decreased level of rig activity (lowest since April 1951) continues, this nation's outlook for an ample supply of crude sufficient for emergencies *is not good*.

The President's Cabinet Committee on Fuel and Energy Resources Report recommending that imports should not significantly exceed the 1954 ratio to domestic crude oil production was issued in February 1955. It is more than a coincidence that in only 10 months' time — a very short period for an economic enterprise as large as the petroleum industry—drilling activity began a decline which has continued to this day — more than 16 months. It is indeed seldom that a conclusion has so clearly been proven correct by the course of subsequent events.

The events of Suez have pointed up the necessity for a surplus of oil producing and transporting capacity. Such surpluses can be created only over a long period of time. Surpluses cannot be created, and indeed will vanish when a continually growing segment of the domestic market is denied to domestic producers.

Should you decide to have further headings on this matter, our Association would appreciate an opportunity to appear. Our staff maintains considerable statistical data on drilling activity, crude reserves and the like, and we shall be happy to provide you any additional information available you may need.

Very truly yours,
(Signed) Jack H. Abernathy

Rotary Drilling Rigs Operating in United States and Canada

Monthly Average

	1951		1952		1953		1954	
Month	U. S.	Canada	U. S.	Canada	U. S.	Canada	U. S.	Canada
January	2229	101	2779	171	2518	164	2491	148
February	2049	100	2709	177	2468	156	2508	141
March	2176	100	2699	180	2466	162	2553	152
April	2317	102	2755	160	2528	144	2604	150
May	2442	120	2830	176	2564	135	2560	117
June	2518	129	2782	183	2620	184	2542	115
July	2598	136	2489	168	2626	162	2480	154
August	2598	136	2341	164	2618	175	2400	150
September	2781	156	2401	177	2614	182	2361	119
October	2878	161	2522	187	2710	170	2402	157
November	2930	158	2655	179	2781	154	2523	190
December	2975	163	2710	178	2827	157	2708	206
Average	2551	132	2642	174	2612	162	2515	150

	1955		1956		1957		
Month	U. S.	Canada	U. S.	Canada	U. S.	Canada	
January	2409	193	2720	201	2339	229	
February	2455	202	2482	222	2294	241	
March	2588	202	2647	226	2425	240	
April	2618	132	2694	119	2383	139	(3 weeks)
May	2663	108	2724	183			
June	2732	176	2756	243			
July	2698	208	2622	245			
August	2728	213	2522	253			
September	2752	214	2526	252			
October	2768	194	2556	242			
November	2850	208	2572	249			
December	2991	197*	2721	230			
Average	2688	188	2628	222			

*Peak, 3137 rigs on December 19, 1955.

Laboratory studies show how to...

Combat Water-Coning By Injecting Reverse-Wetting Additives

Results indicate that oil production can be substantially improved in highly permeable reservoirs afflicted with water-coning

Alan S. Michaels,
R. I. Bergman,
and
D. L. Brown
Massachusetts Institute of Technology

INJECTION of reverse-wetting additives may prove a valuable method of improving the productivity of oil wells delivering large quantities of water because of coning. Laboratory studies have illustrated that in highly permeable formations, treatment of coned-out wells by aqueous solutions of certain additives alter the capillary forces to the point of preventing or minimizing water intrusion.

In these studies, conducted at Massachusetts Institute of Technology, using a small-scale model of a water drive reservoir, several conclusions have been reached. Although not definitely proved, the duration of improvement in oil production is believed to be adequate for practical purposes. Effectiveness of the treatment in low permeability formations is yet to be determined.

Water-coning, or the encroachment of water into the oil-bearing stratum immediately below the well, is but one cause for the loss of oil production.

In the primary recovery of petroleum for water-drive reservoirs, and in secondary recovery from waterflood projects, the efficiency of oil production is often greatly reduced by the premature intrusion of water into the oil-bearing stratum, and the simultaneous delivery of oil and water. In many instances, this appears to be caused by inefficient displacement of oil by the advancing water front, thus leaving a large fraction of the oil trapped in the formation.

Improvement in the efficiency of displacement of oil by water evidently involves physical or chemical modification of the entire producing formation, or of the displacing aqueous phase. On the other hand, since water-coning is a process confined essentially to the immediate vicinity of the wellbore, alteration of the properties of the formation (or formation fluids) immediately surrounding the wellbore holds promise for alleviation of this condition.

The object of this investigation was to explore the possibilities of minimizing or eliminating water-coning by chemical treatment (via fluid injection) of the formation adjacent to the wellbore, in order to alter the capillary forces acting at the oil-water interface.

A laboratory apparatus, consisting of a cylinder of 20-40 mesh Ottawa sand to which oil (kerosine) and water were fed peripherally and from the center of which the fluids could be withdrawn at a controlled rate via an axially located perforated tube, was used for this study. The oil-to-water ratio in the produced fluid was measured as a function of flow rate and location of the oil-water horizon in the cylinder, with the sand untreated (i.e., water-wet). Small quantities of dilute (50 ppm) aqueous solutions of two reverse-wetting additives (octadecyl amine acetate, and dioctadecyl dimethyl ammonium chloride) were then forced out into the sand via the perforated tube, and the oil-water ratio redetermined at varying flow rates and interface locations.

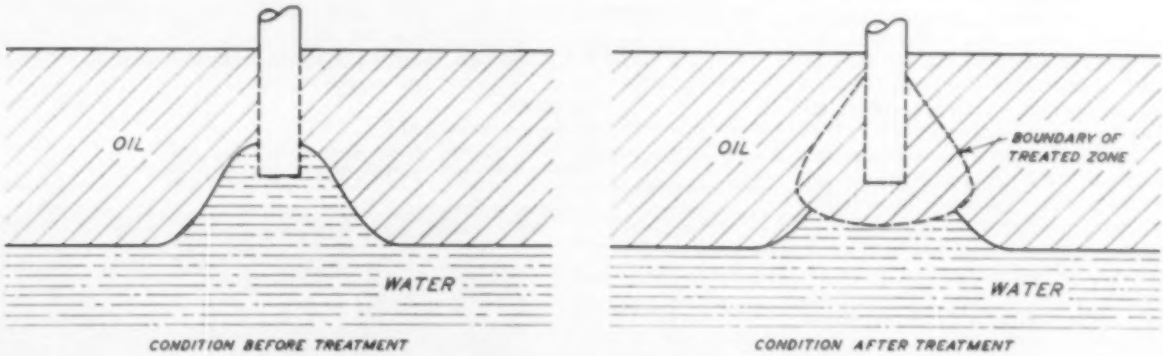

FIG. 1. **Water-coning** condition, as illustrated by the first schematic, is altered by chemical treatment with reverse-wetting additives to the extent shown in the second schematic.

It was found that, under conditions where prior to formation treatment, no oil was delivered, treatment with these additives resulted in the production of fluid containing as much as 67 percent oil, the oil-to-water ratio decreasing with increasing flow rate. Under conditions where, prior to treatment, the produced fluid contained 24 percent oil, after treatment as much as 100 percent oil was delivered. Of the two additives studied, the amine salt was found to be the more beneficial.

Theory of Water-Coning

In an ideal, horizontal water-drive reservoir, from which only oil is being removed at some point in the oil-saturated region, radial transport of oil to the well point is effected solely by the vertical migration of the water table into the oil-filled region. There are, therefore, no horizontal pressure gradients in the water-zone, since there is no horizontal movement of water. In the immediate neighborhood of the well-point, however, there is both a horizontal and a vertical pressure gradient in the oil zone resulting from flow of oil into the well. As pointed out by Muskat,[7] the deficiency in hydraulic pressure due to fluid flow at a point near the well is accompanied by (neglecting capillary effects) a rise in the water table at that point to a level such that the net reduction in hydrostatic head (relative to the normal level of the water table) is exactly equal to the pressure deficiency. Since, in radial flow, the pressure gradient increases rapidly in the vicinity of the well, this causes the water table to assume the characteristic conical shape, with its apex at the wellbore.

Water Breakthrough

Muskat and Wyckoff[7] attempted to analyze mathematically the factors influencing the degree of water-coning, and the conditions under which breakthrough of water into a well was likely to occur. Their derivation involved certain simplifying assumptions, the most important of which appeared to be that the oil-flow and pressure distribution around the wellbore in the presence of the cone was the same as that which would have been obtained had coning not occurred. Capillary effects were also neglected.

Their calculations revealed that the height of the water-cone increased (a) as the pressure difference between the wellbore and formation increased, (b) as the depth of penetration of the well into the oil-bearing stratum increased, and (c) as the thickness of the oil-bearing stratum decreased. Of particular interest are their calculations showing the maximum pressure differentials and oil-flow rates which could be maintained without breakthrough of water into the well. A few of these figures are shown in Table 1.

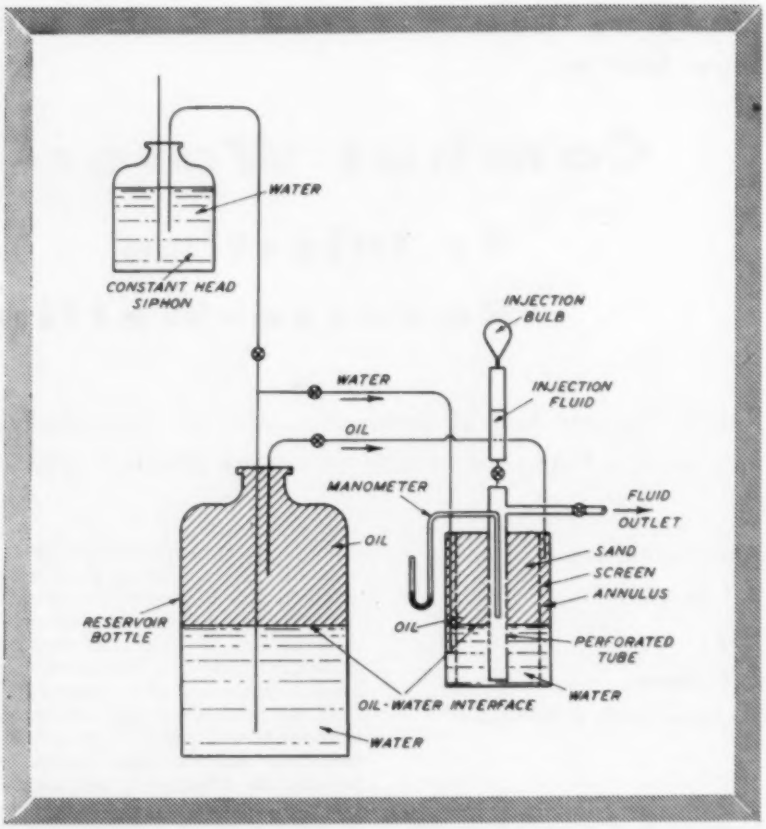

FIG. 2. **Apparatus** used in the MIT lab studies of water-coning. Top bottle furnishes water drive pressure for the reservoir bottle. Oil and water being "produced" is drawn from axially located perforated tube in the well unit at right.

These results indicate that only very small pressure differentials are required to establish water cones of appreciable height — for example, a differential of 0.1 atm can produce a 7.5 ft cone, and a differential of 3.4 atm can produce a 100 ft cone. Furthermore, the data suggest that very minor changes in draw-down pressure can result in the conversion of a 100 percent oil-producing well into one producing substantial quantities of water.

Muskat's and Wyckoff's analysis of the coning process, despite the limitations imposed by their simplifying assumptions, undoubtedly gives a reasonable qualitative picture of conditions before entry of water into the well. Once water production has been established, however, their analysis is no longer applicable, and no similar analysis for the case of simultaneous oil-and water-flow under coning conditions has been found.

Since flow of water from a cone into a well must be accompanied by horizontal and vertical pressure gradients

TABLE 1. Critical Conditions for Water-Cone Breakthrough.
(Data of Muskat and Wyckoff.[7])

Assumptions:
Formation radius: 500 ft
Wellbore radius: ¼ ft
Density difference between oil and water: 0.3 gm per cc

Thickness of oil-bearing zone, ft	Percent penetration of well into oil zone %	Critical pressure differential at which water will enter well, atm	Oil flow rate at critical pressure bbl/day
15	50	0.1	16
15	80	0.03	5.5
75	50	0.8	560
75	80	0.2	200
200	50	3.4	5500
200	80	0.8	2000
200	90	0.3	850

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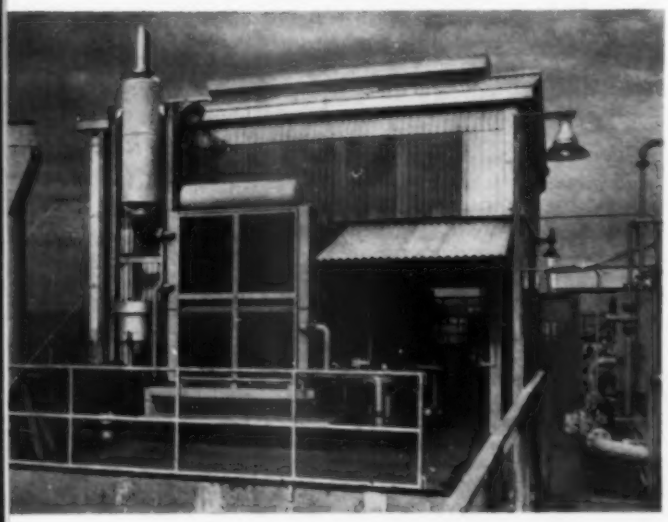

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which tend to suppress the cone, it is to be expected that:

A. Height of rise of the oil-water intreface into the producing section of the wellbore will be less sensitive to draw-down pressure than is the height of the cone before breakthrough, and

B. Water-oil ratio will be dependent upon, among other variables, the draw-down pressure, the ratio of permeabilities of the oil and water-saturated zones, and the ratio of viscosities of the two phases.

If, however, the permeability and viscosity ratios are not far from unity, then differences in the radial pressure gradients in both the water-cone and the oil zone should be small, and nearly equal to the hydrostatic head of the water forming the cone. This suggests that the forces which would be required to suppress the cone and thus to prevent water-encroachment may also be small. Indeed, the successes realized in preventing coning by deposition of gelatinous materials in the pores of the formation directly below the wellbore,[4] and by plug-back cementing[5] appear to support this hypothesis.

Influence of Capillary Forces

This analysis was made on the assumption that capillary forces acting at the oil-water interface were non-existent. If one considers that, in a completely water-wet porous formation (i.e., solid-water contact angle = 0 deg), there exists a pressure discontinuity across the oil-water boundary where the two phases meet at menisci in the pores of the formation, the qualitative effect of capillary phenomena on the coning process can easily be illustrated.

Assuming the radius of curvature of the menisci to be, say 1.0 micron, and assuming an oil-water interfacial tension of 30 dynes per cm, the pressure on the oil at the water table will be approximately 0.6 atm higher than that on the water immediately below it. This, in turn, means that the pressure differential at the wellbore above which water breakthrough occurs will be reduced by the capillary pressure gradient across the oil-water interface.

In other words, the tendency of water to rise by capillarity actually causes the water-cone to migrate to a higher level than predicted by simple hydrodynamics. (A capillary pressure of 0.6 atm, for example, will cause migration of water upward for a distance of over 60 ft through an oil of density of 0.7 gm per cc.) As indicated in Muskat's calculations, only a small change in draw-down pressure is needed to cause water-breakthrough; hence, capillary pressures (with water as the wetting phase) can lead to breakthrough and high-water production under conditions where, in the hypothetical absence of capillarity, no breakthrough would occur.

In normal water-wet formations, therefore, capillary forces appear to favor water-coning. Hence, it may be deduced that alteration of the capillary forces in the neighborhood of a wellbore may be beneficial either in permitting a higher rate of oil production without water-breakthrough, or in reducing the water-oil ratio of a "coned-out" well. Such alteration could be accomplished by (1) reducing the oil-water interfacial tension to a low value, or (2) changing the oil-water-solid contact angle so as to render oil the wetting phase. The latter approach appears to offer advantages over the former, the most important being (a) it makes use of the capillary forces in suppressing the coning tendency, and (b) it may be carried out with a relatively small quantity of a treating agent which adsorbs firmly and nearly irreversibly on the formation surface around the wellbore, rather than the undoubtedly large amounts of surfactant which would have to be continuously supplied to the oil or water phase in order to keep the oil-water interfacial tension at a low value. The probable effect of such treatment is shown schematically in Fig. 1.

"Reverse-Wetting" of Rock Surfaces

The use of capillary active substances to render the surfaces of hydrophilic solids preferentially oil-wettable[9] has been well demonstrated with regard to operations such as ore flota-

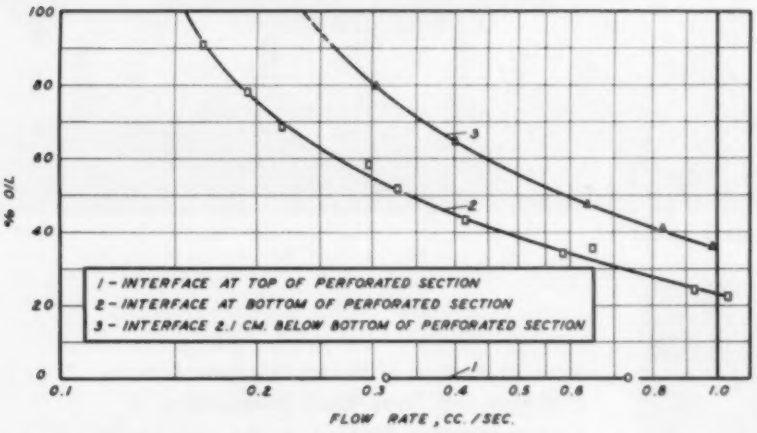

FIG. 3. **Effect of flow rate** and interface location on percent of oil delivered. Untreated sand was used in this phase of the study.

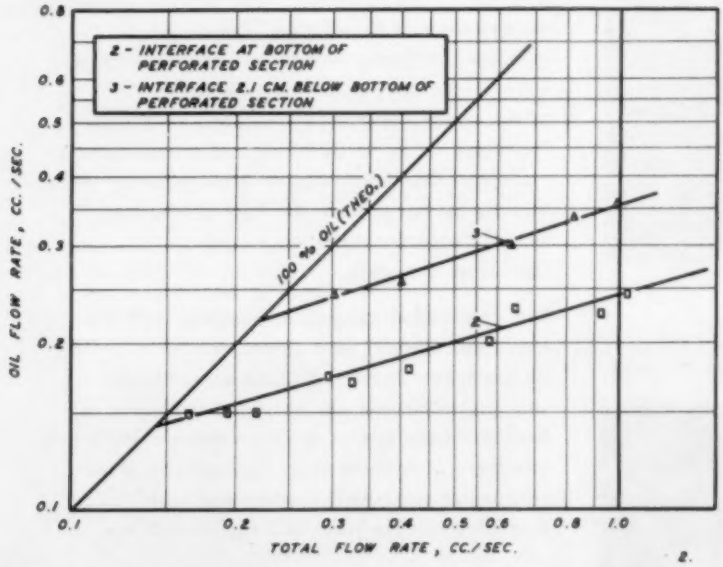

FIG. 4. **Effect of flow rate** and interface location on total oil flow through untreated sand.

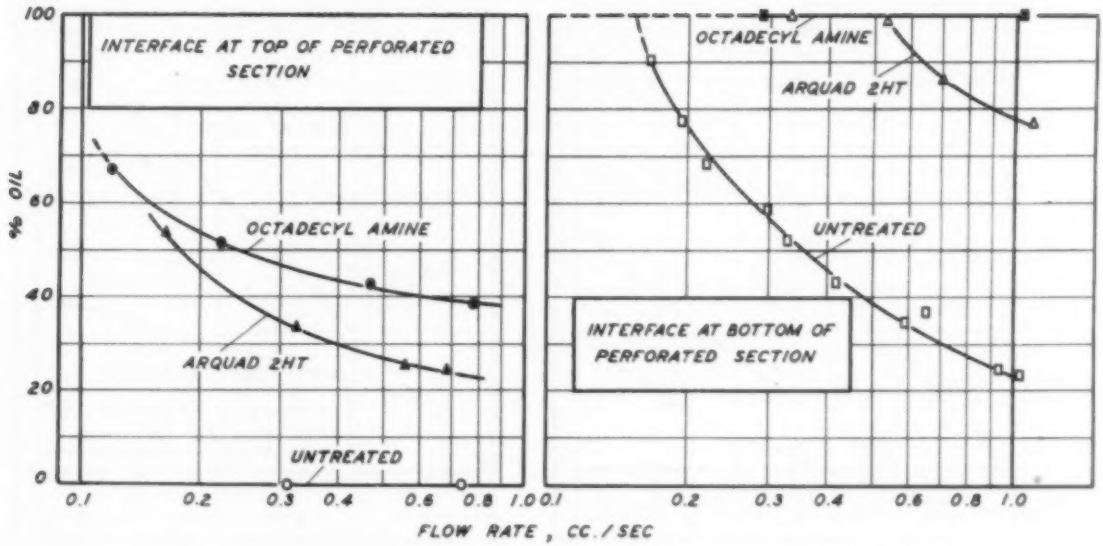

FIG. 5. **Effects are compared** on the flow rate and interface location on percent of oil delivered in both treated and untreated sand, and with the oil-water interface at both top and bottom of the perforated section.

tion,[2] formation of organophilic clays,[3] soil stabilization,[5] etc. Compounds active in this respect are primarily amphipathic molecules whose polar groups have a specific (usually ionic) affinity for atoms or ions on the solid surface. For silica and many aluminosilicates, the fatty amines and fatty quaternary ammonium salts are particularly effective. These compounds are very strongly adsorbed by such solids, and remain firmly attached except in the presence of strongly acidic or basic solutions. TenBrink[1] has described the use of such materials (rosin amine acetate) for reverse-wetting of subsurface siliceous formations.

Reverse-wetting of a porous formation can be accomplished by the simple expedient of permeating the formation with a dilute solution of the surface-active agent. While adsorption of the compound by the solid surface can take place from either aqueous or non-aqueous (i.e., oil) solutions, treatment is believed to be more effective and rapid when conducted with aqueous solutions. The reasons for this belief are (1) the adsorption process appears to be primarily ionic in character, and ionic processes generally take place far more rapidly in polar than in non-polar solvents, and (2) since the solid surfaces are initially water-wet, use of an aqueous solution eliminates the additional resistance to diffusion of the treating agent across an oil-water interface. Furthermore, for treatment of water-cones, use of aqueous treating solutions may be preferable, since it is desired to treat the water-saturated regions into which aqueous solutions might be expected to flow more readily than oil; injection of an aqueous solution into the formation may therefore result in preferential flow of the solution into the "coned-out" region.

LAB PROCEDURES

To test the effect of reverse-wetting on water-oil ratio under "coned-out" conditions, equipment was constructed to permit oil and water to flow simultaneously into unconsolidated sand in a radial flow pattern, fluids being removed from the sand at a controlled rate. The water-oil ratio of the fluid withdrawn was determined as a function of (a) flow rate and (b) oil-water interface location both before and after treatment of the sand by injection.

Apparatus and Materials

Apparatus used for this work is shown in Fig. 2 A "model well" was constructed, consisting of a cylindrical column of unconsolidated Ottawa sand (through 20, on 40 mesh) measuring approximately 10.5 cm in diameter by 16 cm high, surrounded by a 40-mesh stainless steel screen, and confined in a glass jar about 11 cm in inside diameter. Along the long axis of this cylinder was inserted a copper tube 1.28 cm in outside diameter, sealed at the bottom and perforated for distance of 7.0 cm beginning 6.0 cm from the sealed end. The perforated section was covered externally with a layer of 40-mesh screen (making the effective outside diameter 1.46 cm) to permit uniform flow of fluid into the tube. The lower end of the perforated section was located 6.6 cm above the bottom of the sand cylinder. The open end of the tube was fitted with a needle valve by which flow rate was controlled, and a length of ⅛-in. copper tubing was inserted into the tube bore and brought out through the side, by means of which the hydrostatic pressure at the perforated section was measured.

A large carboy, containing oil and water, was connected via tygon tubing to the model well, so that both oil and water could flow into the 2.5 mm annulus between the sand cylinder and confining jar. Hydrostatic pressure was applied to the contents of the carboy by means of a constant-head water-siphon. The total hydrostatic head at the oil-water interface in the carboy was held constant at 4 ft of water. Use of this large reservoir made it possible to hold the oil-water interface at a constant level during operation.

Sand was first screened through a 40-mesh sieve to remove fines, and then washed with chromic acid solution, water, sodium bicarbonate solution, and water, to insure cleanliness of the surface. It was dried, and then sifted into the confining jar (filled with water) to obtain a completely water-saturated system. The porosity of this sand was found to be approximately 0.25.

Kerosine (specific gravity 0.82, viscosity at 25 C approximately 0.8 cp) and laboratory tap water were used as the oil and water phases respectively in these experiments.

Treating agents examined were (1) octadecyl amine (Armeen 18D, Armour Chemical Company), and (2) dioctadecyl dimethyl ammonium chloride (Arquad 2HT, Armour Chemical Company). Dilute aqueous solutions

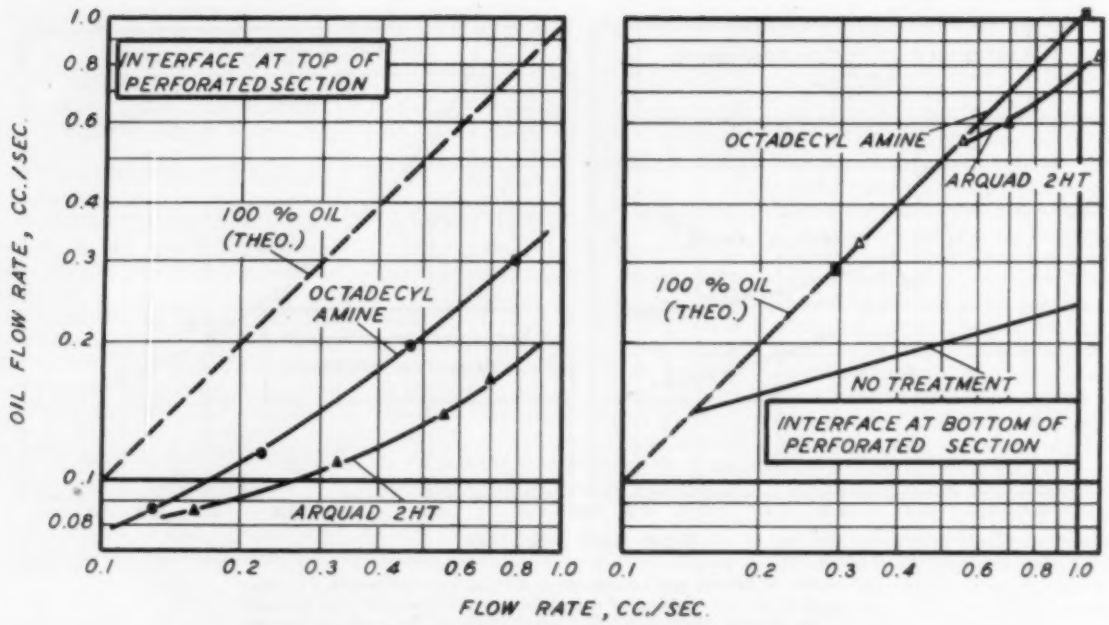

FIG. 6. **Treated and untreated sand** are considered in results, shown here, of the effect of flow rate and interface location on total oil flow.

of the former compound were prepared by dissolving the amine in glacial acetic acid, and adding the salt to water. The latter compound dispersed readily in water to yield a slightly turbid solution. Solutions used for injection contained 50 ppm of the treating agent.

Procedure

After the well-unit had been filled with clean sand and assembled, the needle valve controlling flow from the central tube or "well" was opened slightly to permit fluid to flow out of the unit. Adjustment of screw clamps on the lines from the reservoir allowed both liquids to enter the unit, and permitted the oil-water interface in the annulus between the sand cylinder and the jar to be maintained at a prescribed level. This level was adjusted to be on the same horizontal plane as the level of the interface in the reservoir.

Effluent from the well-unit was collected in graduates, and both the total volumetric flow-rate, and the oil-water volumetric ratio determined at frequent intervals. When no further change in oil-water ratio with time was observed, it was assumed that the system had attained steady-state, and average values of flow-rate, oil-water ratio, and hydrostatic pressure were measured. The same procedure was employed for a range of flow-rates, each change in flow-rate requiring readjustment of the flow of oil and water from the supply reservoir.

Location of the oil-water interface in the well-unit was then changed by raising or lowering the jar and readjusting the screw clamps on the feed lines, and the above procedure repeated. Three oil-water interface locations were studied:

1. Interface at the top of the perforated section of the central tube,
2. Interface at the bottom of the perforated section, and
3. Interface 2.1 cm (30 percent of the height of the perforated section) below the bottom of the perforated section.

Treatment of the sand with the reverse-wetting agents was carried out in the following manner: After flow-measurements on the clean sand were completed (for a specified oil-water interface location), flow was stopped, and approximately 25 cc of a solution containing 50 ppm of the treating agent was forced down into the central tube and out into the sand by means of a rubber aspirator bulb, using kerosine as a displacing fluid. (Assuming uniform radial flow outward of the solution, this should have resulted in the treatment of a layer of sand about 1.5 cm thick around the perforated section of the tube.) Flow of fluid was then re-established, and conditions allowed to reach steady state, after which measurements of flow-rate and oil-water ratio were made as described above. After completion of these measurements, the sand was discarded, and fresh sand used for each subsequent treatment.

Test Results

Results of this study, showing percent oil delivered, and total oil production, as a function of flow-rate, for both treated and untreated sand, and for varying location of the oil-water interface, are presented in Table 2 and Fig. 3 to 6.

DISCUSSION OF RESULTS

Flow Rate and Interface Location On Oil Delivery (Untreated Sand)

Fig. 3 shows the variation in the percentage of oil in the produced fluid as a function of flow-rate for the three interface locations studied, under conditions where the sand is untreated and water-wet. When the oil-water horizon in the formation lies at or below the bottom of the perforated section, practically water-free oil is produced below a certain flow-rate; at a critical flow-rate (whose magnitude evidently increases as the oil-water horizon is lowered), sensible quantities of water begin to appear in the effluent, and the percentage of oil in the delivered fluid proceeds to decrease with increasing flow-rate.

When the oil-water horizon lies at or above the top of the perforated section, evidently no oil is produced from the formation (at least in the flow-rate range studied here.) It seems doubtful, under these conditions, that oil could be produced at exceedingly low flow-rates; however, at very high flow-rates, "reverse-coning" of oil into the water-filled regions is likely to occur. Evidently the flow-rates used in this study were too low for this effect to be observed.

TABLE 2. Summarized Data and Calculations.

Location of oil-water interface	Injection treatment	Flow rate, cm³/sec	Flow rate, bbl/day per ft³ of formation	Approx. pressure drop, mm Hg	Percent oil in fluid produced	Oil flow rate, cc/sec
Top of Perf. Section	None	0.312	4.9	1.0—2.6	0.0	0.0
		0.731	11.5		0.0	0.0
	25 cc of 50 ppm sol'n octadecyl amine acetate	0.129	2.0	0.4—3.2	66.9	0.086
		0.221	3.5		51.3	0.113
		0.463	7.3		42.6	0.197
		0.772	12.1		38.3	0.296
	25 cc of 50 ppm sol'n Arquad 2HT	0.159	2.5	1.6—3.4	53.7	0.086
		0.324	5.1		33.7	0.109
		0.553	8.7		25.2	0.139
		0.682	10.7		24.4	0.167
Bottom of Perf. Section	None	0.165	2.6	0.4—3.2	90.5	0.149
		0.193	3.1		77.9	0.150
		0.219	3.4		68.5	0.150
		0.295	4.6		58.4	0.175
		0.327	5.1		52.0	0.170
		0.415	6.6		43.3	0.179
		0.582	9.2		34.5	0.201
		0.649	10.2		35.6	0.230
		0.925	14.5		24.2	0.224
		1.03	16.1		23.8	0.245
	25 cc of 50 ppm sol'n octadecyl amine acetate	0.289	4.5	1.0—4.8	100	0.289
		1.02	16.0		100	1.02
	25 cc of 50 ppm sol'n Arquad 2HT	0.330	5.2		100	0.330
		0.530	8.3	3.4—7.4	99.5	0.528
		0.698	10.9		86.0	0.600
		1.09	17.1		76.9	0.836
2.1 cm below bottom of Perf. Section	None	0.304	4.8	1.3—3.1	79.7	0.243
		0.400	6.3		64.4	0.258
		0.634	10.0		47.3	0.300
		0.829	13.0		40.8	0.338
		0.985	15.5		35.9	0.354

Of practical importance is the variation in total oil production as a function of flow-rate. This is shown graphically in Fig. 4. It is apparent that, despite causing a reduction in the oil-content of the produced fluid, increasing the flow-rate causes a moderate increase in oil delivery. It is of interest that, above the critical flow-rate at which water breakthrough occurs, the rate of oil delivery is roughly proportional to the 0.28 power of the total flow-rate, this exponent being nearly independent of the location of the interface.

Clearly, however, the location of the oil-water interface is far more important in determining oil-production than is the total flow rate; as the data show, lowering the water table a distance of only 30 percent of the height of the perforated section increases oil delivery (for a given total flow-rate) by a factor of about 1.4, while the same increase in delivery (for a given interface location) would require an increase in flow-rate of about three-fold. Suppression of the oil-water meniscus would, therefore, appear to be a more effective way to improve oil production from a coned-out well than would increasing the gross flow of fluid from the well.

Pressure-drops across the sand cylinder accompanying withdrawal of fluid were, unfortunately, too low to be measured accurately with available equipment. Over the flow-rate range studied (0.13-1.09 cc per sec), the pressure drop varied from approximately 0.4 to 4.8 mm Hg, representing drawdown pressures of between 0.0005 to 0.0006 atm. These pressures are substantially lower than those indicated in Table 1; it should be noted, however, that the "penetration" of the well into the oil-zone in this model was never less than about 83 percent, and the thickness of the formation only 16 cm, with the result that the critical pressure at water breakthrough should be far lower than the lowest value cited in Table 1. In general, the trends of the data are qualitatively consistent with the predictions cited in Part 2 above.

Effect of Injection on Reverse-Wetting Additives

Results of injecting 25 cc of 50 ppm aqueous solutions of octadecyl amine acetate and Arquad 2HT (dioctadecyl dimethyl ammonium chloride) into the sand immediately surrounding the perforated tube are shown in Table 2 and Fig. 5 and 6.

For the case where the oil-water interface was located at the top of the perforated section (where, without treatment, no oil was produced) injection treatment resulted in the delivery of a rather high percentage of oil in the effluent. For both treating agents, it is seen from Fig. 5 that the fraction of oil in the delivered fluid decreases with increasing flow-rate, the curves being similar in shape to those of Fig. 3. Octadecyl amine acetate appears to be more effective than Arquad 2HT, particularly at the higher flow-rates.

For the case where the oil-water interface was maintained at the bottom of the perforated section, treatment with octadecyl amine acetate resulted in production of 100 percent oil over the entire flow-rate range studied. With Arquad 2HT, 100 percent oil was produced up to a critical flow-rate of about 0.5 cc per sec. Above this flow-rate, the fraction of oil in the effluent began to decrease in a fashion similar to that noted above.

The effect of injection treatment upon oil flow-rate as a function of total flow-rate is shown in Fig. 6. With the interface at the top of the perforated section, treatment with both additives not only permitted production of oil under conditions where normally none would be produced, but also caused the oil flow-rate to increase rather rapidly with total flow-rate. The fractional improvement in oil productivity resulting from injection of either additive in this case was obviously infinite, but treatment with octadecyl amine appeared to give about 50 percent better performance than Arquad 2HT.

With the interface at the bottom of the perforated section, treatment with either additive resulted in as much as a 2.5-fold increase in oil production at a flow-rate of 0.5 cc per sec. Above a total flow-rate of 0.57 cc per sec, octadecyl amine was the more effective additive, since it continued to permit production of water-free oil. At the highest flow-rate studied (1.01 cc per sec), this additive permitted about a four-fold increase in oil production. Presumably, the same oil production might be achieved without treatment by increasing the total flow-rate; extrapolation of the data indicates, however, that this would require a 140-fold increase in flow-rate, and would yield an effluent containing about 0.7 percent oil. This would, offhand, appear to be an unattractive alternative to injection-treatment.

Trends of the data, as plotted on Fig. 5 and 6, strongly suggest that the action of injection-treatment with reverse-wetting additives is primarily to depress the oil-water interface in the vicinity of the wellbore, and thus to cause the well to behave as if the oil-water horizon were at a lower level. Inasmuch as the volume of treating solution used was sufficient to contact only a small volume of the formation around the bore, the disturbance of the oil-water profile must have been confined to the immediate vicinity of the bore.

If this picture is correct, then it would appear that the observed reduction in water-flow after treatment is

caused by capillary blockage of water by oil in the oil-wet region. This blockage will remain effective only if the hydrostatic pressure difference across the interface (due to differences in flow-rate of the two fluids) is equal to or less than the capillary pressure difference. This in turn means that reverse-wetting of the formation in the immediate vicinity of the wellbore will probably be effective in preventing or reducing water-flow only if the drawdown pressure at the wellbore (and hence the pressure gradient near the wellbore) is low, as found in this study. Since, however, the horizontal pressure gradient decreases exponentially with distance from the wellbore, treatment of the formation for a distance of several bore diameters from the well may permit effective water blockage even at rather high drawdown pressures.

Treatment Durability

Of great practical importance is, of course, the durability of such a treatment — that is, how long a single injection treatment will produce the desired effects. It has been observed in this study that continuous operation of the model for several days after injection resulted in no detectable change in oil-water ratio or oil recovery. Whether operation for several weeks or months would have shown a gradual loss in effectiveness cannot be ascertained from this work; in view, however, of the extremely strong adsorption of fatty amines and related compounds by silica, it seems likely that these additives will continue to exert their reverse-wetting effects over long periods of continuous leaching with oil or water.

Low Permeability

This study was performed on coarse sand of very high permeability, for which the pressure gradients required to obtain high flow-rates are inordinately low. The question naturally arises as to whether comparable results would be obtained with low permeability formations. Since permeability is nearly directly proportional to the square of the mean pore diameter, and capillary forces, to the reciprocal of the first power of the diameter, one might predict a decrease in the importance of capillary effects as permeability decreases. It must, however, be kept in mind that permeability is a function of *mean* pore diameter, whereas capillary forces are a function of *minimum* pore diameter; since little is known as to how these two quantities vary with respect to one another in porous media of differing porosity, particle size, and particle size distribution, prediction of the effect of reverse-wetting on coning in low-permeability formations is merely speculative. Further studies on various types of porous media will be needed to answer this question.

It also would appear that this type of treatment would be effective mainly in homogeneous, isotropic formations. In highly fractured reservoirs, where the fractures are both wide and interconnected, capillary forces will probably be of minor importance in controlling the movement of water or oil through the fissures. If, on the other hand, fractures are not interconnected, or are small, very narrow, and uniformly distributed, capillary forces may be of sufficient magnitude to permit control of water intrusion by reverse-wetting.

CONCLUSIONS

The results of this study lead to the following conclusions.

In a small-scale model of a water drive reservoir, where (1) the formation is a water-wet, highly permeable sand, and (2) the oil-water viscosity ratio is close to unity, if the oil-water interface lies above the perforated section of the wellbore, only water is produced. If the oil-water interface lies at or slightly below the bottom of the perforated section, oil and water are produced simultaneously, the proportion of oil decreasing with increasing flow-rate. There is a critical flow-rate, dependent on interface location, below which only oil is produced. Total oil production increases with increasing flow-rate, and varies roughly as the 0.28 power of the total flow-rate.

Treatment of the sand in the immediate vicinity of the wellbore by injection of dilute aqueous solutions of reverse-wetting additives permits a marked increase in oil-production and oil-water ratio when, before treatment, substantial quantities of water were produced. Of the two additives examined in this work (octadecyl amine acetate, and dioctadecyl dimethyl ammonium chloride), the former was found to be the more effective.

Duration of improvement in oil production resulting from injection has not been ascertained, but is believed to be adequate for practical purposes.

Effectiveness of the treatment in low permeability formations, or in geometrically more realistic systems, is open to question. Further studies along this line are now in progress.

Acknowledgment

The experimental work described in this paper was performed as an SB thesis in chemical engineering at the Massachusetts Institute of Technology by R. I. Bergman and D. L. Brown (June 1955). This study represents part of a broad program of fundamental and applied research being conducted by the MIT Soil Stabilization Laboratory. Financial and technical assistance of The Western Company, Midland, Texas, whose interest in this subject prompted the investigation, is gratefully acknowledged.

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Texas Depth Contender Off to Fast Start

A quick start was given Phillips Petroleum Company's 22,000-ft test in Pecos County, West Texas. The Texas depth title contender is being drilled by Great Western Drilling Company with a new heavy-duty all-electric rig.

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Great Western's new Rig 44 is the first heavy capacity unit to take full advantage of an electric drive and a new engine-generator arrangement.

The rig's transmission is made up of three drilling generators that supply power to four shunt-wound drilling motors each rated at 625 hp continuously and 1000 hp intermittently for drawworks duty. Two motors will be connected directly to the drawworks and one engine to each of the two main mud pumps. Two 450-hp diesel engines will be directly coupled to each generator.

Any of the generators may be used to drive the rotary table. The generators are constructed so that two 450-hp engines drive each unit. In case of emergency, either of the two engines, in the package, placed at opposite ends of the generator, may be operated while the other is being repaired.

The well to be drilled is the No. 1-A Montgomery, and if carried to full contract depth will top the Texas depth record of 19,060 ft.

Graphic Method Used In . . .

Predicting Gas-Condensate Well Productivity

Richardo C. Prian
Petroleos Mexicanos, Mexico City, D. F. Mexico
and
Orlando R. Gomez
Petroleos Mexicanos, Coatzocoalcos, Veracruz, Mexico

Gas flow rate, within 10 percent error, can be predicted by knowing: Static bottom-hole pressure or depth of productive interval; permeability; productive interval and size of tubing

A SERIES of charts has been developed to determine within an error of about 10 percent the predicted rate of gas flow, measured at atmospheric conditions, obtainable from newly-drilled gas condensate wells. It is necessary to know the following variables: (1) Static bottom-hole pressure or depth of productive interval; (2) formation permeability; (3) length of productive interval, and (4) tubing size. The greater the accuracy of these data, the smaller the percent of error in final results.

By this method, it is also possible to determine the approximate size choke necessary to obtain a desired production rate, as well as determine the maximum rate for open flow, that is, the maximum capacity of the tubing for different static bottom-hole pressures.

After performing a hydraulic fracture treatment to a productive well when wellhead pressures and production are known, permeability variations can be predicted. It is also possible to predict the change of production and wellhead pressure when the length of the productive interval is changed.

One of the first problems to be solved when a gas-condensate reservoir is discovered is to estimate the various rates of flow of gas and the corresponding wellhead pressures expected. To solve such a problem, herein is described a method which requires as the only known data the mean depth of the productive formation and its permeability. When the formation permeability is unknown, its value can be estimated from calculated permeabilities obtained from

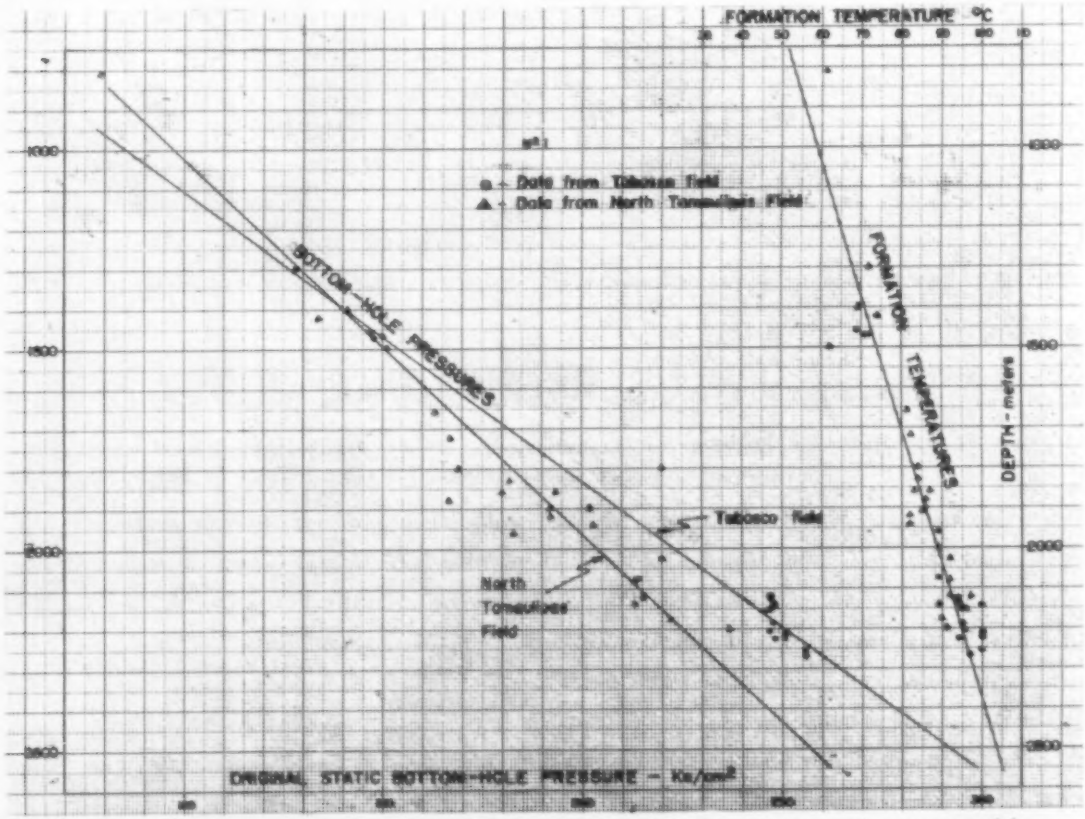

FIG. 1. **Relationship between depth** of producing interval with original static bottom-hole pressure and formation temperature. Depth is in meters, pressure in kilograms per square centimeter absolute, and temperature in degrees Centigrade.

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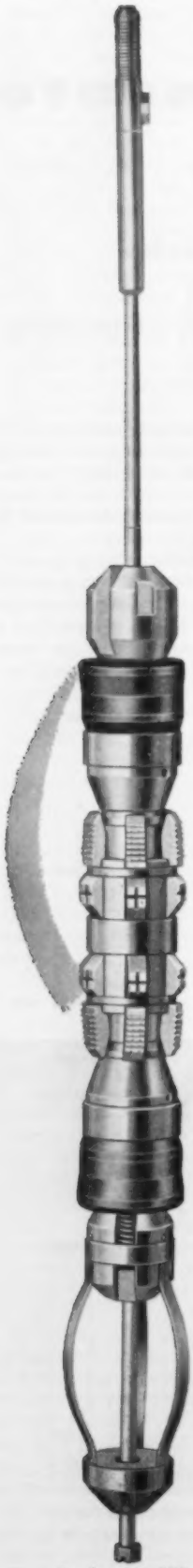
as many intervals as required



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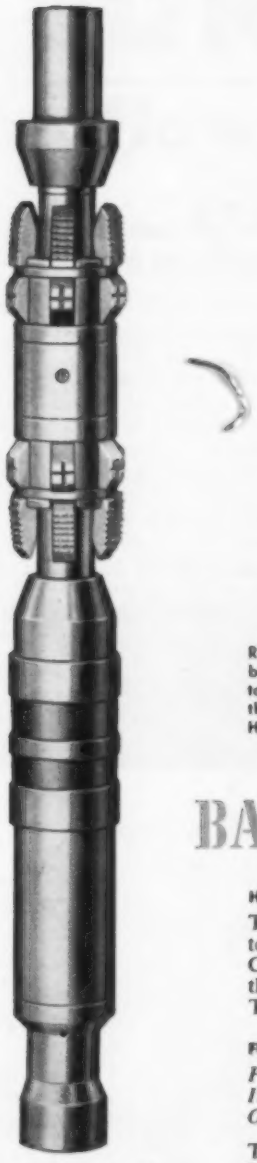

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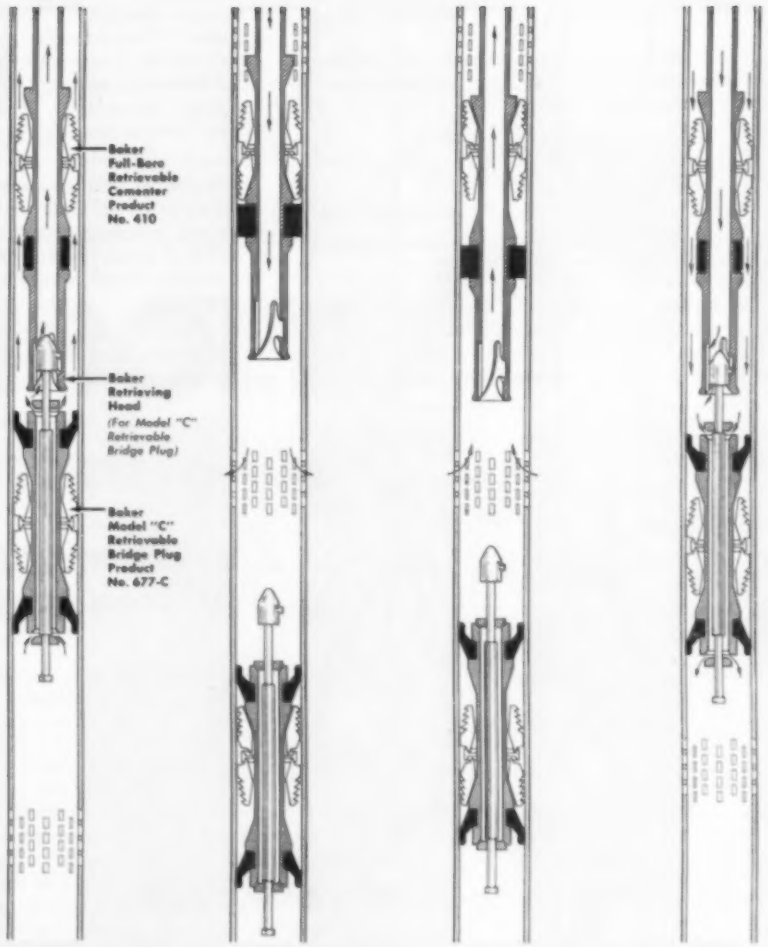

RUNNING-IN
Retrievable Bridge Plug being run into well on bottom of Full-Bore Cementer through use of Retrieving Head. Note fluid by-pass.

FRACTURING OR ACIDIZING
Plug should be pressure tested after release. Cementer is released, raised above perforations and reset for pressure operations.

SWABBING, TESTING
Note how the reversal of pressure differential has transferred load from one set of slips to the other (both cementer and plug).

RETRIEVING
Plug and Cementer being moved to next set of perforations—or retrieved from well. Valves in plug open to permit fluid by-pass.

BAKER FULL-BORE RETRIEVABLE CEMENTER

HOLDS PRESSURE FROM EITHER ABOVE OR BELOW

Two sets of opposed slips enable the cementer to hold pressure from either above or below. Casing can be tested before squeeze—and the tubing also, if the Baker Full-Bore Tubing Tester is used.

FULL BORE CONSTRUCTION

Permits Passage of Tubing Perforators or Instruments—Assists in Preventing "Screen-Out" on Fracturing Jobs

The Full Bore through the Cementer (and Tester if used) is in reality a continuation of the bore through the tubing.

This continuous full ID passage not only permits passage of tubing perforators or instruments but assists in preventing "Screen-Out" (sand dropping out of the oil) and subsequent plugging of the tubing in fracturing jobs.

IDEAL STRADDLE TOOL WHEN USED WITH BAKER RETRIEVABLE BRIDGE PLUG

The operation of the Cementer setting mechanism makes it easy (through the use of the Retrievable Bridge Plug Retrieving Head) to release and pick-up the Baker Retrievable Bridge Plug. It is in fact the ideal partner to the Retrievable Bridge Plug for selective multiple-zone or single-zone operations.

these products and their application

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well potential tests in reservoirs of similar lithologic characteristics.

For the José Colomo field in Tabasco, Mexico, the following equation relates the permeability with the lithologic characteristics of the producing sand:[7]

$$K = \text{Log}_{10}\left(\frac{R_{NL}}{7.39}\right)^{36.8}$$

where:

K = Effective permeability, md. (obtained from well potential data).

R_{NL} = Apparent resistivity of the formation, ohm/m²/meter.

Apparent permeability. In this report, values of the "Kh" factor shown in the charts, defined as the productive capacity of the formation, refers to the interval h subject to exploitation and to the apparent permeability ranges of the formation obtained from well potential data with the Darcy equation. These permeability values have been found to be quite different from permeabilities obtained from core analysis of formation samples. This apparent permeability is the "average" permeability of the permeabilities of the mud filtrate invaded zone and the non-invaded zone around the well.

The graphic solution shown here is derived from the combined equations of Darcy and Smith. Even though the problem could be solved analytically resolving the resultant equation, this is a cumbersome and time consuming method. For this reason, charts were drawn covering a sufficient range of conditions.

It is believed that the manner in which the charts were constructed is one of the most practical ways of covering the different variables involved.

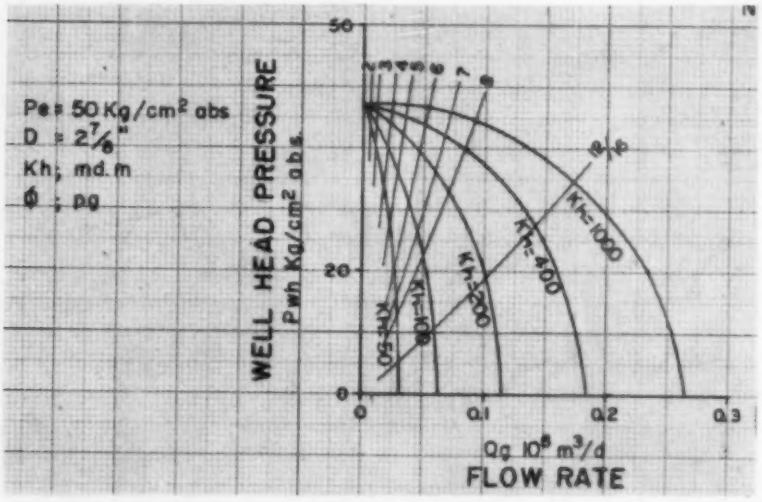

FIG. 2. **Flow rates vs wellhead pressures** where bottom-hole pressure is 50 Kg per sq cm absolute and tubing size is 2⅞-in. for various choke sizes and Kh millidarcy-meter) values.

Standard Conversion Factors

1 meter = 3.281 ft.

1 Kg/cm² = 14.223 lb per sq in.

1 cubic meter = 35.314 cu ft.

°F = 1.8 °C + 32.

°K = °C + 273.

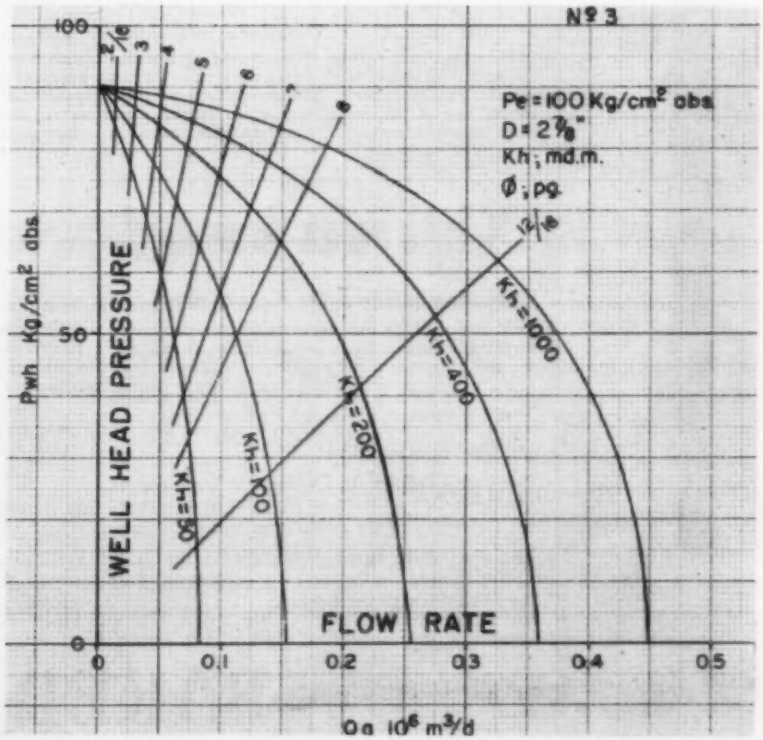

FIG. 3. **Flow rates vs wellhead pressures** where bottom-hole pressure is 100 Kg per sq cm absolute and tubing size is 2⅞-in. for various choke sizes and Kh (millidarcy-meter) values.

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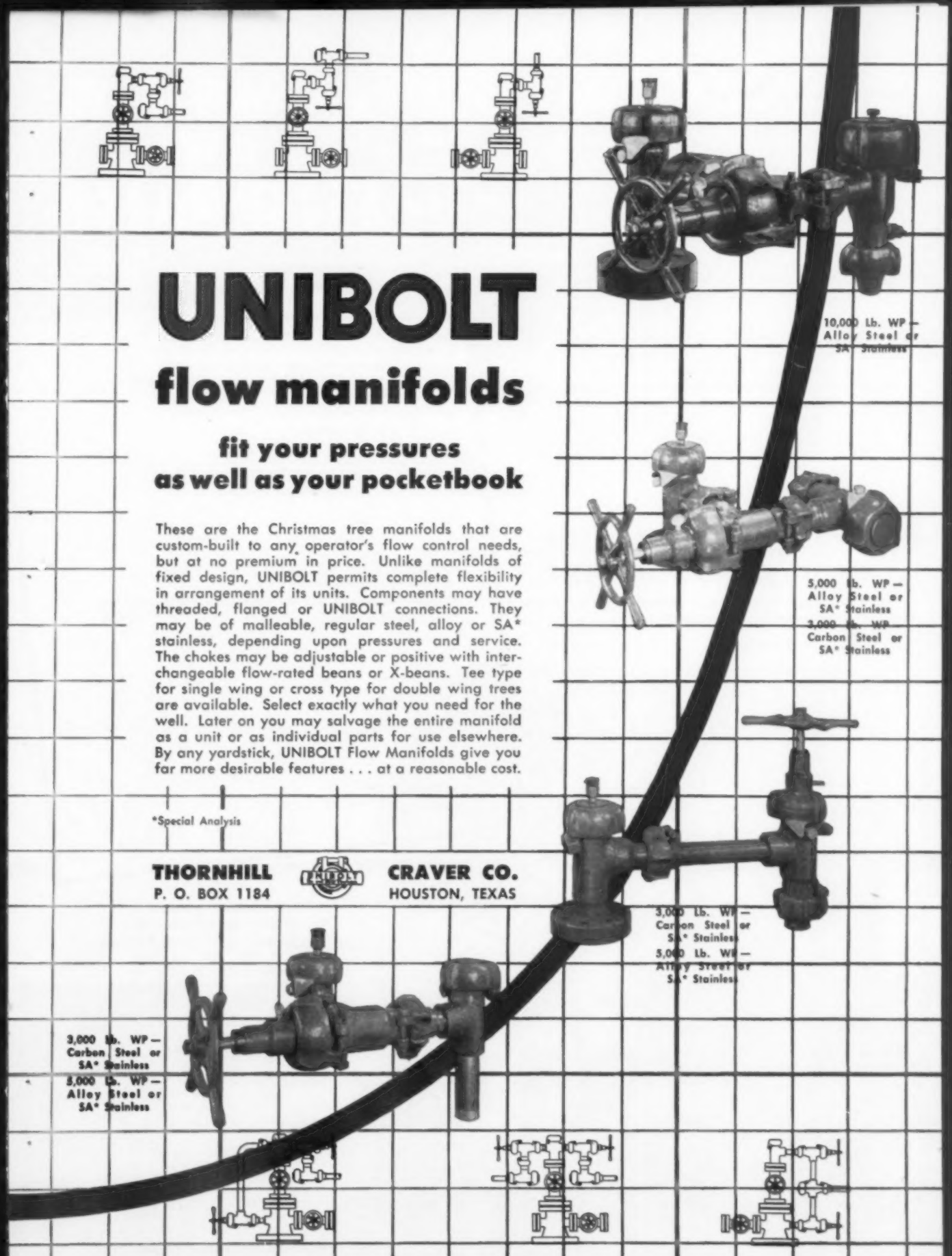
10,000 Lb. WP — Alloy Steel or SA* Stainless
5,000 Lb. WP — Alloy Steel or SA* Stainless
3,000 Lb. WP — Carbon Steel or SA* Stainless
5,000 Lb. WP — Carbon Steel or SA* Stainless
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3,000 Lb. WP — Carbon Steel or SA* Stainless
3,000 Lb. WP — Alloy Steel or SA* Stainless

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Development of Method

Fig. 2 through 10 were drawn using equation:

$$Q_g = \sqrt{\left(\frac{B}{2C}\right)^2 - B\,(e^s P^2_{wh} - P^2_e)} - \frac{B}{2C} \quad . \quad . \quad (1)$$

where:

Q_g = Volume rate of flow of gas, m³ per 24 hours. (Absolute base pressure: 1 atmosphere, and base temperature: 60 F).
P_{wh} = Wellhead pressure, Kg/cm²abs.
P_e = Bottom-hole pressure of the reservoir, Kg/cm²abs.
e = Natural logarithm base = 2.71828.

constant B is obtained from equation:

$$B = A^2 \frac{1/f\, d^5}{e^s - 1} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where:

d = Inside diameter of tubing, in.

A, 1/f and s are obtained from equations:

$$A = \frac{4397.71}{\overline{Z}\,\overline{T}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

$$1/f = 16\,[\log_{10}(5692.3\ d)]^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

and:

$$S = 0.06835 \frac{G_m L}{\overline{Z}\,\overline{T}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

where:

$\overline{Z}$ = Supercompressibility factor of the gas-condensate mixture at mean flow conditions inside the tubing; dimensionless.
$\overline{T}$ = Mean flow temperature inside the tubing; °Kelvin.
1/f = Transmission factor, dimensionless.
G_m = Average specific gravity of mixture inside the tubing (Air − 1) = 0.700 (See footnote 1).
L = Mean depth of productive interval; m.

The constant C is obtained from equation:

$$C = 0.0114 \frac{T_a K_a h}{P_a Z_y T_y \mu_g \log_{10} \frac{r_e}{r_w}} \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where:

T_a = Base temperature of measured gas, °Kelvin.
T_y = Reservoir temperature, °Kelvin.
K_a = Apparent effective permeability of the formation (gas); md.
h = Productive interval, in meters, m.
P_a = Base pressure of measured gas, 1.033 Kg/cm² abs.
Z_y = Supercompressibility factor of gas at mean flow conditions in the reservoir, dimensionless.
μ_g = Gas viscosity at mean flow conditions in reservior, centipoises.
r_e = Drainage radius, meters. (See footnote 2).
r_w = Well radius, meters.

(Footnote No. 1)—This specific gravity corresponds to a mixture produced with a gas-condensate ratio of 6000 m³/m³, the gas specific gravity being 0.638 and the condensate specific gravity being 0.787 (water —1). These specific gravities are average values for this particular type of reservoir. Its value was calculated from Equation 4.

$$G_m = \frac{G_g + \frac{818\ G_c}{R}}{1 + \frac{200}{R}}$$

where:

G_g = Specific gravity of gas at separator (air = 1).
G_c = Specific gravity of condensate at separator (water = 1).
R = Gas-condensate ratio, m³/m³.

(Footnote No. 2)—In this paper r_e = 500 meters and r_w = 0.109 meters (8¾ in. hole diameter), but large variations of these factors do not have practical influence on the final results.

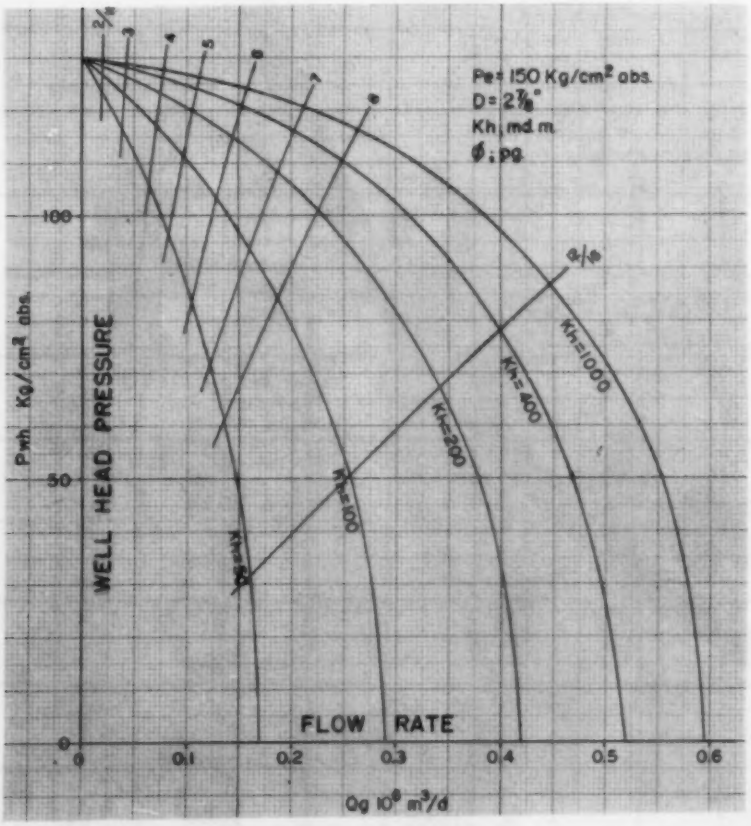

FIG. 4. **Bottom-hole pressure** is 150 Kg per sq cm absolute (2133.45 psi) and tubing size is 2⅞-in. in this plot of flow rate in cubic meters per day vs wellhead pressure in kilograms per square centimeter absolute for various choke sizes and Kh values.

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GRAHAM, TEXAS

April 24, 1957

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The Wheland Company
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EXPORT DISTRIBUTORS: LUCEY EXPORT CORPORATION—233 Broadway, New York 7, New York—Broad Street House, London, E. C. 2, England.

Source of Data

Bottom-hole pressures. The original static bottom-hole pressure can be obtained through one of the following equations:

$$P_e = 0.1067\,L - 8.52 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7)$$

This equation was obtained from statistical data of gas-condensate reservoirs in North Tamaulipas, Mexico.[1] (See Fig. 1.)

$$P_e = 0.13792\,L - 52.34 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

This equation was obtained from statistical data of the gas-condensate reservoir in Tabasco, Mexico. (See Fig. 1.)

where:

(See footnote 3).

P_e = Original static bottom-hole pressure, Kg/cm² abs.

L = Depth of the producing formation, meters.

Equation 4 is a variation of Nikuradse's equation,[2] and a roughness factor of 0.00065 in. is used for the tubing.

Reservoir temperature. The reservoir temperature was obtained through equation:

$$t = 0.030\,L + 29 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

obtained from statistical data of gas-condensate reservoirs in North Tamaulipas and Tabasco, Mexico. (See Fig. 1.)

where:

t = Formation temperature, °C.

L = Formation depth or mean depth of productive interval, meters.

The Authors

Richardo C. Prian is a petroleum engineer transferred December 1956 to Petroleos Mexicanos offices in Mexico City from Coatzacoalcos, Veracruz where for the past five years he was in charge of reservoir engineering. He finished petroleum engineering studies at the National University of Mexico in 1946, and underwent 18 months training in Pemex's general reservoir petroleum engineering department before working as a field engineer.

Orlando R. Gomez is a petroleum engineer for Petroleos Mexicanos in charge of the reservoir petroleum engineering department at Coatzacoalcos, Veracruz. He was graduated from the National Polytechnic Institute of Mexico in 1953, and after a training period in the general petroleum reservoir engineering department in Mexico City, was made assistant reservoir petroleum engineer at Coatzacoalcos, Veracruz. He was placed in charge of this group in December 1956. He is a junior member of Society of Petroleum Engineers, AIME.

The average temperature in the flow-string, $\overline{T}$, (deg Kelvin), was obtained through equation: (See footnote 4).

$$\overline{T} = 0.94\,t + 273 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

(Footnote No. 3)—The P_e values used in the charts are intermediate values between those obtained from equations 7 and 8.

(Footnote No. 4)—Equation 10 is empirical, obtained from temperature surveys in flowing wells at mean flow conditions.

The gas viscosity at mean flow conditions in the reservoir was obtained using the charts on page 41 of Reference 3.

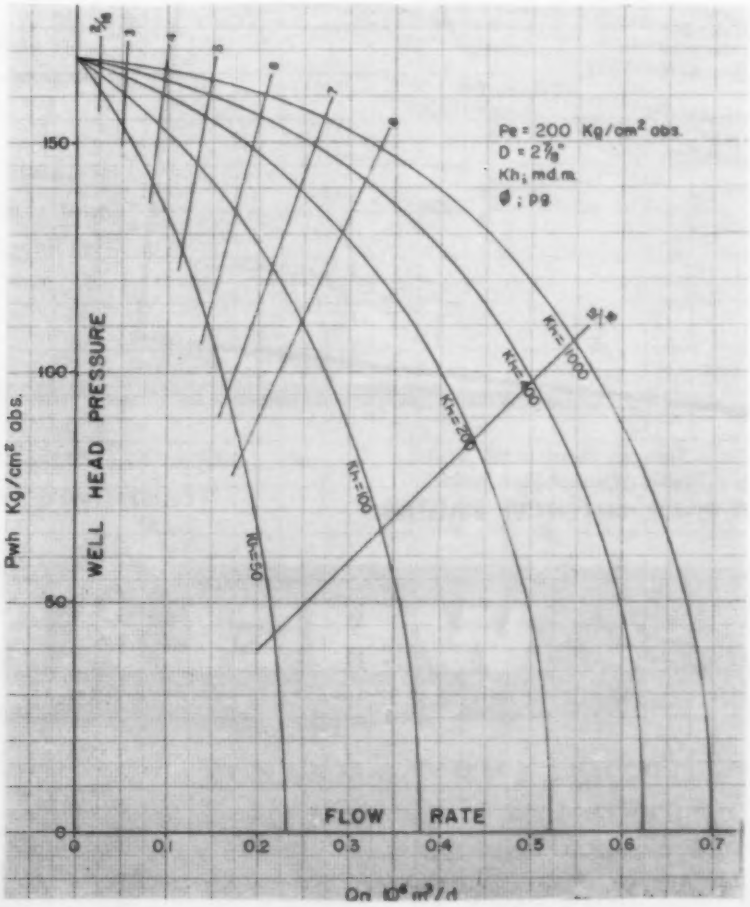
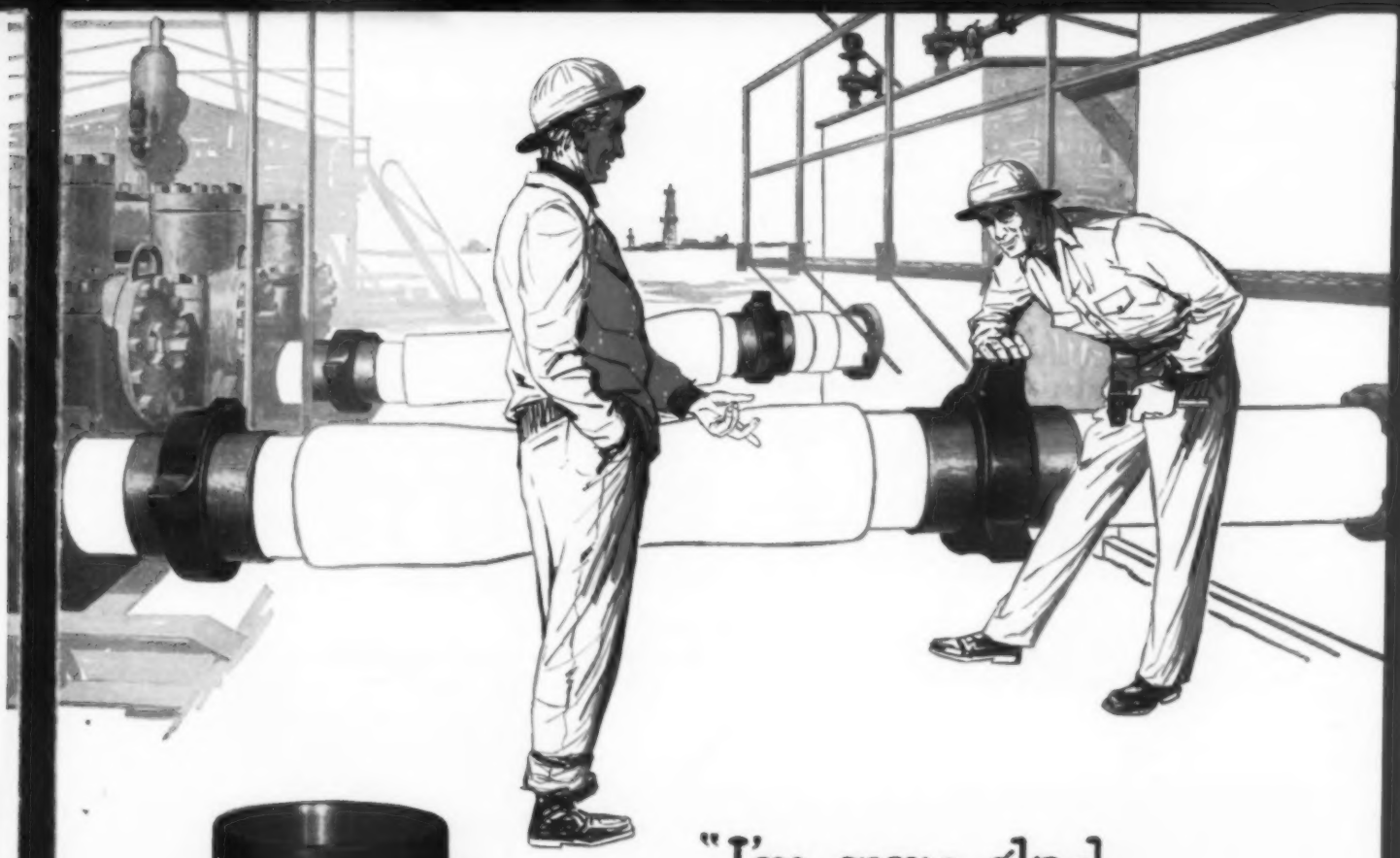


FIG. 5. **Flow rate vs wellhead pressure** where bottom-hole pressure is 200 Kg per sq cm absolute and tubing is 2⅞-in. OD for various choke sizes and Kh values.



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The charts illustrated in this paper were constructed for the following cases:

Bottom-hole Static Pressure, Kg/cm²abs.	Mean depth of formation, meters	Average Formation Temp. °C	O D of Tubing, Inches	I D of Tubing, Inches
50	647	50	2⅞	2.441
100	1063	60	2⅞	2.441
150	1480	75	2⅞	2.441
200	1893	85	2⅞ & 3½	2.441 & 2.992
250	2314	100	2⅞ & 3½	2.441 & 2.992
300	2732	110	2⅞ & 3½	2.441 & 2.992

Choke size. To calculate the size of the choke nipple the following equation was used:[4]

$$Q_g = 402.107\ E\ P_{wh}\ F_{TF}\ F_G\ F_{PV} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

where:

Q_g = Volume of flow of gas, cu meters per 24 hours (base pressure = 1 atmosphere and base temperature = 60 °F).
E = Coefficient of the choke nipple.
P_{wh} = Wellhead pressure, Kg/cm² abs.
F_{TF} = Flowing temperature factor.
F_G = Specific gravity factor.
F_{PV} = Supercompressibility factor.

To calculate the wellhead pressure the following expression was obtained from Equation 19. (See Appendix):

$$P_{wh} = \sqrt{\frac{1}{e^s}} \times \sqrt{P^2_e - \left(\frac{Q^2_g}{B} + \frac{Q_g}{C}\right)}$$

when $Q_g = 0$, that is when the well is shut in:

$$P_{wh} = \sqrt{\frac{P^2_e}{e^s}}$$

Examples of Application

Well "A"

Known:

L = Mean depth of producing interval = 2151.5 meters.
h = Length of producing interval = 33 meters.
K = Apparent effective permeability of formation = 21 md.
Kh = 693 md-meters.
D = OD of tubing = 2⅞-in.
ϕ = Choke nipple size = 3/16-in.

Calculate:

Q_g = Volume rate of flow of gas, cu meters per 24 hours.
P_{wh} = Wellhead pressure, Kg/cm² abs.

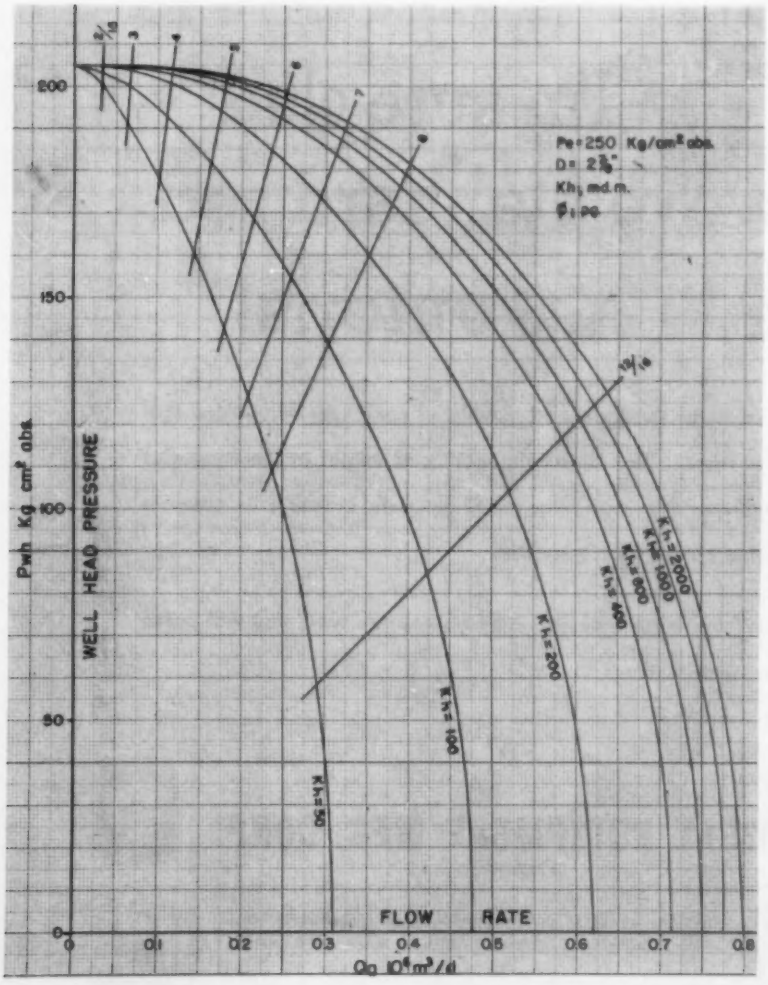

FIG. 6. **Bottom-hole pressure** is 250 Kg per sq cm absolute and tubing size is 2⅞-in. OD in this plot of wellhead pressure vs flow rates for various choke sizes and Kh (millidarcy meter) values.

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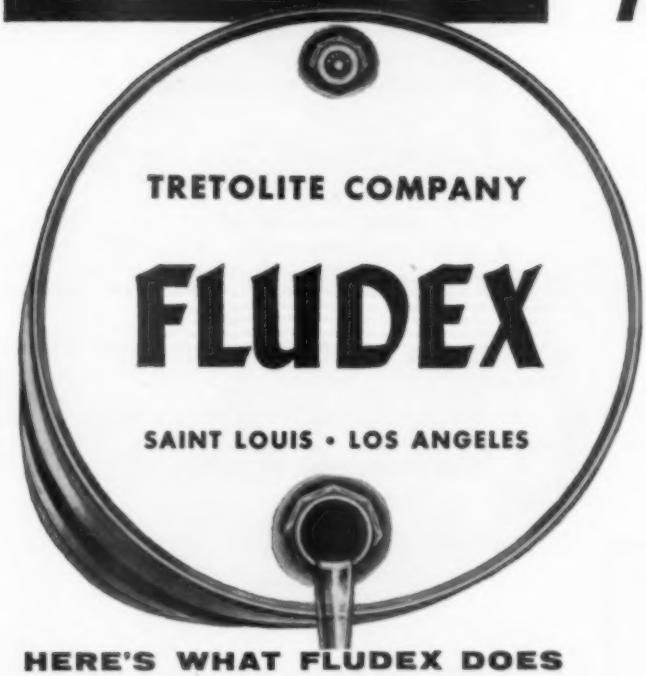

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1. From Equation 8 we obtain:

P_e = Static bottom-hole pressure = 244 Kg/cm² abs.

2. With P_e and OD of tubing known, the values obtained in Fig. 5 and 6 are interpolated:

For Fig. 5.

Given: P_e = 200 Kg/cm² abs.
Kh = 693 md-meters.
ϕ = 3/16-in.

The following is obtained:

Q_g = 55,000 cu meters per 24 hours.
P_{wh} = 166 Kg/cm² abs.

For Fig. 6.

Given: P_e = 250 Kg/cm² abs.
Kh = 693 md-meters.
ϕ = 3/16-in.

The following is obtained:

Q_g = 65,000 cu meters per 24 hours.
P_{wh} = 205 Kg/cm² abs.

Interpolating for P_e = 244.4 Kg/cm² abs., we obtain:

Q_g = 63,800 cu meters per 24 hours.
P_{wh} = 200 Kg/cm² abs.

The measured values obtained after the completion of the well were:

Q_g = 63,344 cu meters per 24 hours.
P_{wh} = 203.9 Kg/cm² abs.

Accuracy of the calculated values:
In production: 0.72 percent.
In wellhead pressure: 1.9 percent.

Well "B"

Known:

L = 2211.5 meters.
h = 33 meters.
K = 15.5 md.
Kh = 512 md-meters.
D = 2⅞-in.
ϕ = 3/16-in.

Calculate:

Q_g = Volume rate of flow of gas, cu meters per 24 hours.
P_{wh} = Wellhead pressure Kg/cm² abs.

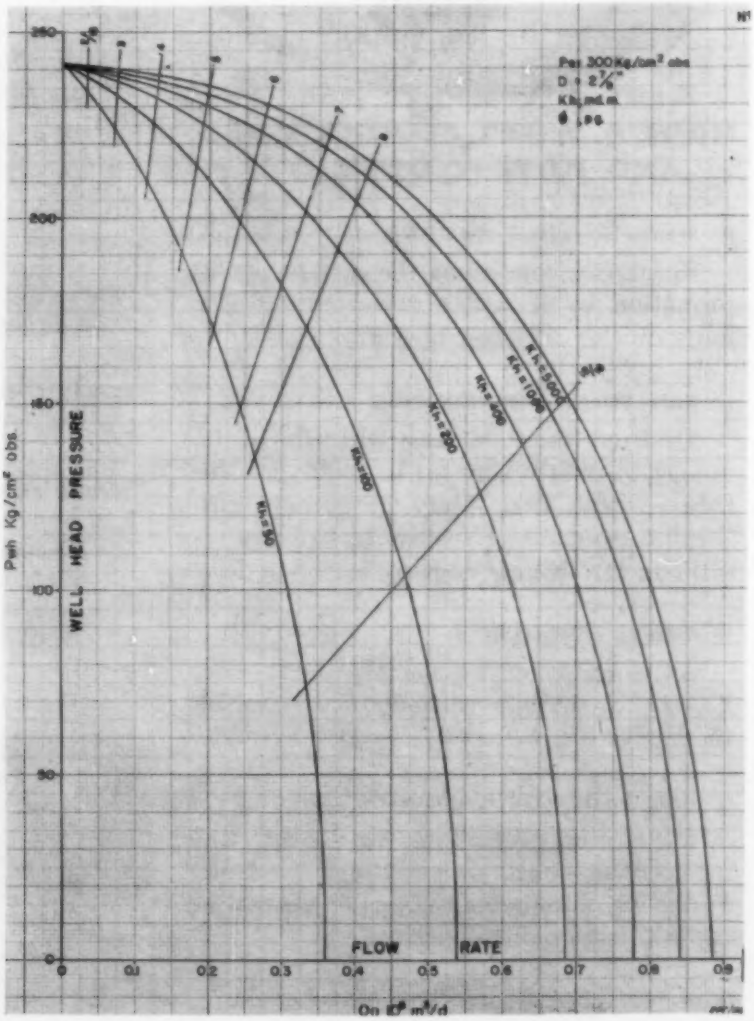

FIG. 7. **Flow rate vs wellhead pressures** where bottom-hole pressure is 300 Kg per sq cm absolute and 2⅞-in. OD tubing for various choke sizes and Kh values.

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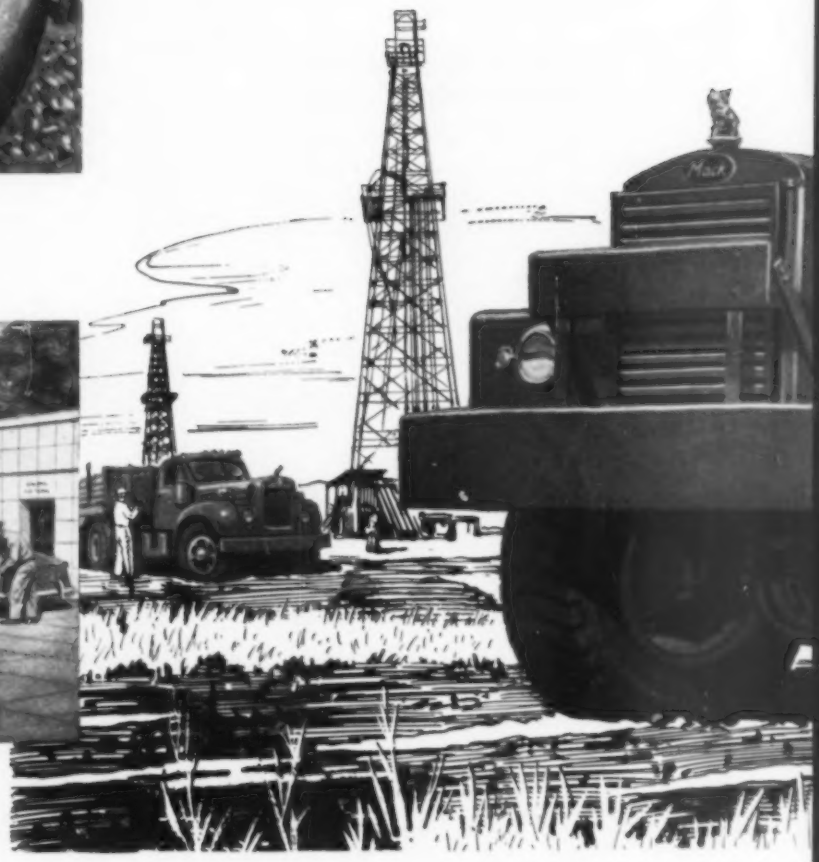

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1. From Equation 8:

$P_e = 252.7$ Kg/cm² abs.

2. From Fig. 6:

$Q_g = 67{,}256$ cu meters per 24 hours.
$P_{wh} = 204.5$ Kg/cm² abs.

3. From Fig. 7:

$Q_g = 75{,}000$ cu meters per 24 hours.
$P_{wh} = 238.5$ Kg/cm² abs.

Interpolating for $P_e = 252.7$ Kg/cm² abs.; we obtain:

$Q_g = 67{,}669$ cu meters per 24 hours.
$P_{wh} = 206.3$ Kg/cm² abs.

The measured values obtained after the completion of the well were:

$Q_g = 63{,}379$ cu meters per 24 hours.
$P_{wh} = 200.7$ Kg/cm² abs.

Accuracy of the calculated values:

In the production: 6.8 percent.
In the wellhead pressure: 3.2 percent.

APPENDIX

Smith's Equation in Reference 5 is:

$$Q = 19686\left(\frac{1}{\overline{Z}\,\overline{T}}\right) \times \sqrt{1/f} \times \sqrt{\frac{d^5\,P^2_w - e^s\,P^2_{wh}}{e^s - 1}} \quad . \quad . \quad . \quad (12)$$

Changing Smith's equation to metric units[6] we obtain:

$$Q_g = 4397.71\,\frac{\sqrt{1/f}}{\overline{Z}\,\overline{T}} \times \sqrt{\frac{d^5\,(P^2_w - e^s\,P^2_{wh})}{e^s - 1}} \quad . \quad . \quad (13)$$

where:

Q_g = Volume rate of flow, cu meters per 24 hours (absolute base pressure = 1 atmosphere and base temperature = 60 °F).
$\overline{Z}$ = Effective compressibility of gas, dimensionless.
$\overline{T}$ = Mean temperature inside the tubing, °Kelvin.
f = Friction factor, dimensionless.
d = Inside diameter of tubing, in.
P_w = Flowing bottom-hole pressure at depth L in the well, Kg/cm² abs.
P_{wh} = Wellhead pressure, Kg/cm² abs.
e = Natural logarithm base = 2.71828.
$s = 0.06835\,\frac{GL}{\overline{T}\,\overline{Z}}$
G = Specific Gravity of gas, air = 1.0
L = Length of tubing, meters.

Substituting $A = \frac{4397.71}{\overline{Z}\,\overline{T}}$ (Equation 3 of this paper) in Equation 13 and squaring both sides of the equation, we obtain:

$$Q^2_g = A^2\,\frac{1/f\,d^5}{e^s - 1}\,(P^2_w - e^s\,P^2_{wh}) \quad . \quad . \quad (14)$$

Substituting $B = \frac{A^2\,1/f\,d^5}{e^s - 1}$ (Equation 2 in this paper) in

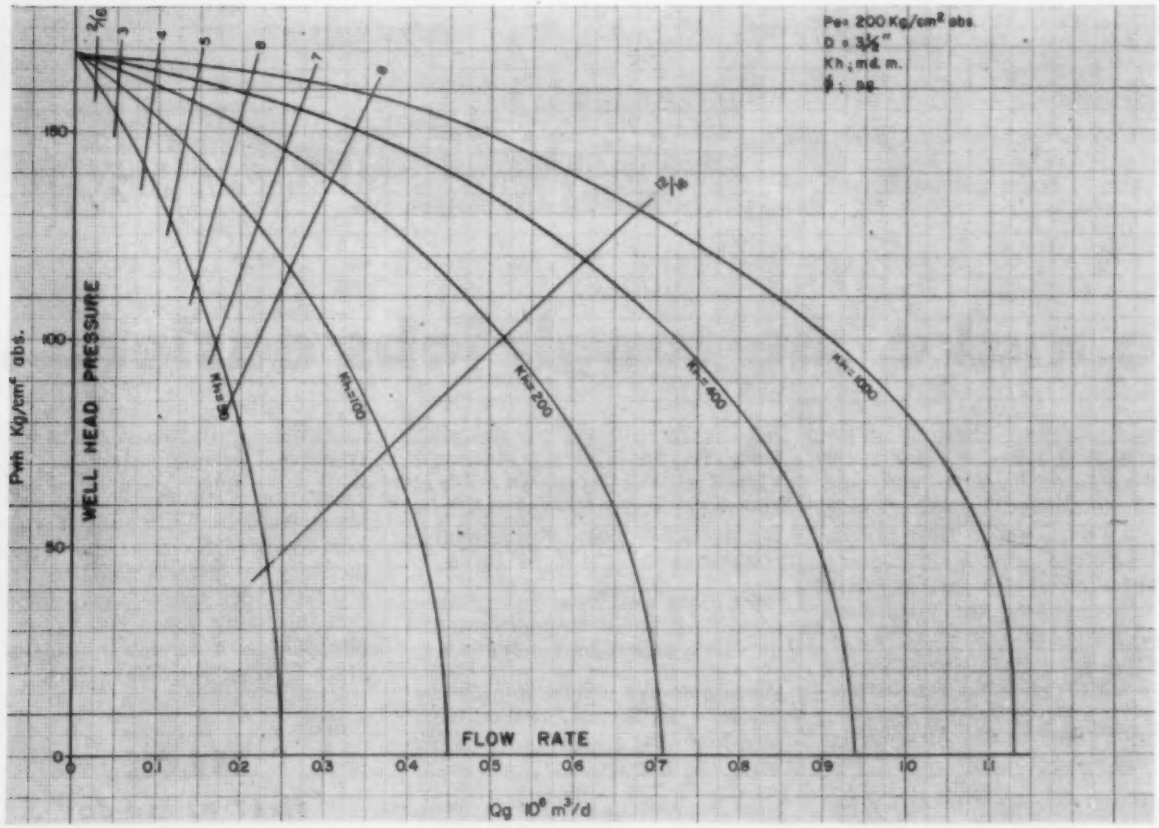

FIG. 8. **Flow rate vs wellhead pressures** where bottom pressure is 200 Kg per sq cm absolute and tubing size is 3¼-in. for various choke sizes and Kh values.

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190-GLBU	6-A	3¾ x 4	265		19	23	27	31	32
195-GKU	6-A	4⅛ x 4	320		20	25	31	36	38
135-GKU	6-A	4¼ x 5	426		28	34	41	47	50
140-GZU	6-A	4⅝ x 5½	554		42	52	62	71	.....
145-GZU	6-A	5⅜ x 6	817		62	77	90	103	.....
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*Features: 4, 6—No. Cylinders; A—Aluminum Pistons; Ir—Cast Iron Pistons

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Equation 14 and solving for P_w, we obtain:

$$P_w = \sqrt{e^s P^2_{wh} + \frac{Q^2_g}{B}} \quad \ldots \ldots \ldots \quad (15)$$

Darcy's equation for radial flow of gases is the following:

$$Q_g = \frac{2\pi K_a h T_a}{P_a Z_y T_y \mu_g} \frac{P^2_e - P^2_w}{\text{Ln}\frac{r_e}{r_w}} \quad \ldots \ldots \quad (16)$$

Changing Darcy's equation to metric units[7] we obtain:

$$Q_g = 0.0114 \frac{K_a h T_a}{P_a Z_y T_y \mu_g \log_{10}\frac{r_e}{r_w}} (P^2_e - P^2_w) \quad . \quad (17)$$

Where:

Q_g^* = Volume rate of flow, cu meters per 24 hours (at T_a and P_a).
h = Interval open production, meters.
P_e = Static reservoir pressure, Kg/cm² abs.
P_w = Flowing bottom-hole pressure, Kg/cm² abs.
T_y = Reservoir temperature, °Kelvin.
μ_g = Gas viscosity, centipoise.
r_e = Drainage radius, meters.
r_w = Well radius, meters.

$$\text{Putting } C = \frac{0.0114 K_a h T_a}{P_a Z_y T_y \mu_g \log_{10}\frac{r_e}{r_w}}$$

Equation 17 takes the form: $Q_g = C (P_e^2 - P_w^2)$ and solving for P_w we obtain:

$$P_w = \sqrt{P^2_e - \frac{Q_g}{C}} \quad \ldots \ldots \ldots \quad (18)$$

Even though reservoirs are capable of producing at high rates, the flow is limited by the size of tubing.

Since a permanent flow is assumed, the rate of flow of gas in the reservoir must be equal to the rate of flow of gas in the tubing, when both are measured at the same conditions of temperature and pressure. Since the volume rate of flow in Darcy's equation refers to flow in the reservoir, and Smith's equation refers to flow through the tubing, the flow that satisfies both conditions is obtained when (15) = (16), that is:

$$\sqrt{e^s P^2_{wh} + \frac{Q^2_g}{B}} = \sqrt{P^2_e - \frac{Q_g}{C}}$$

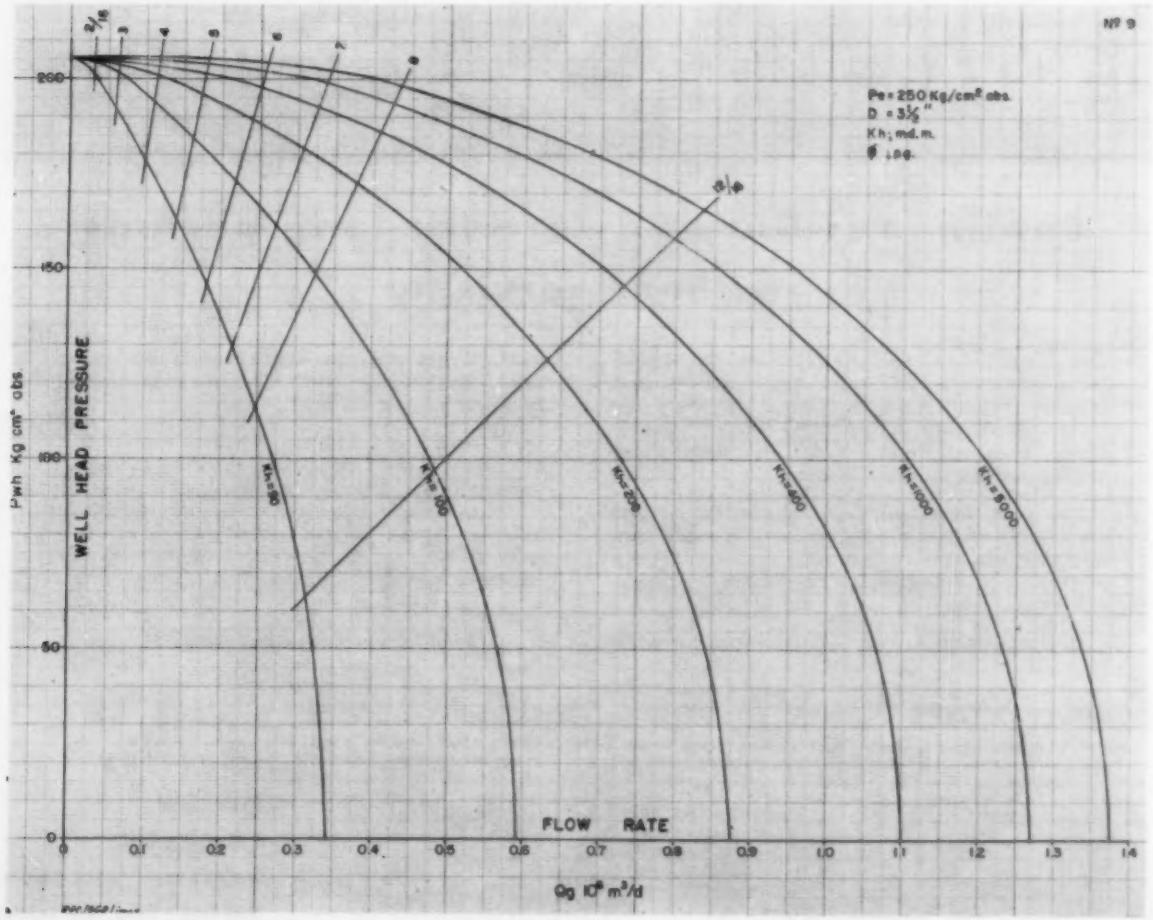
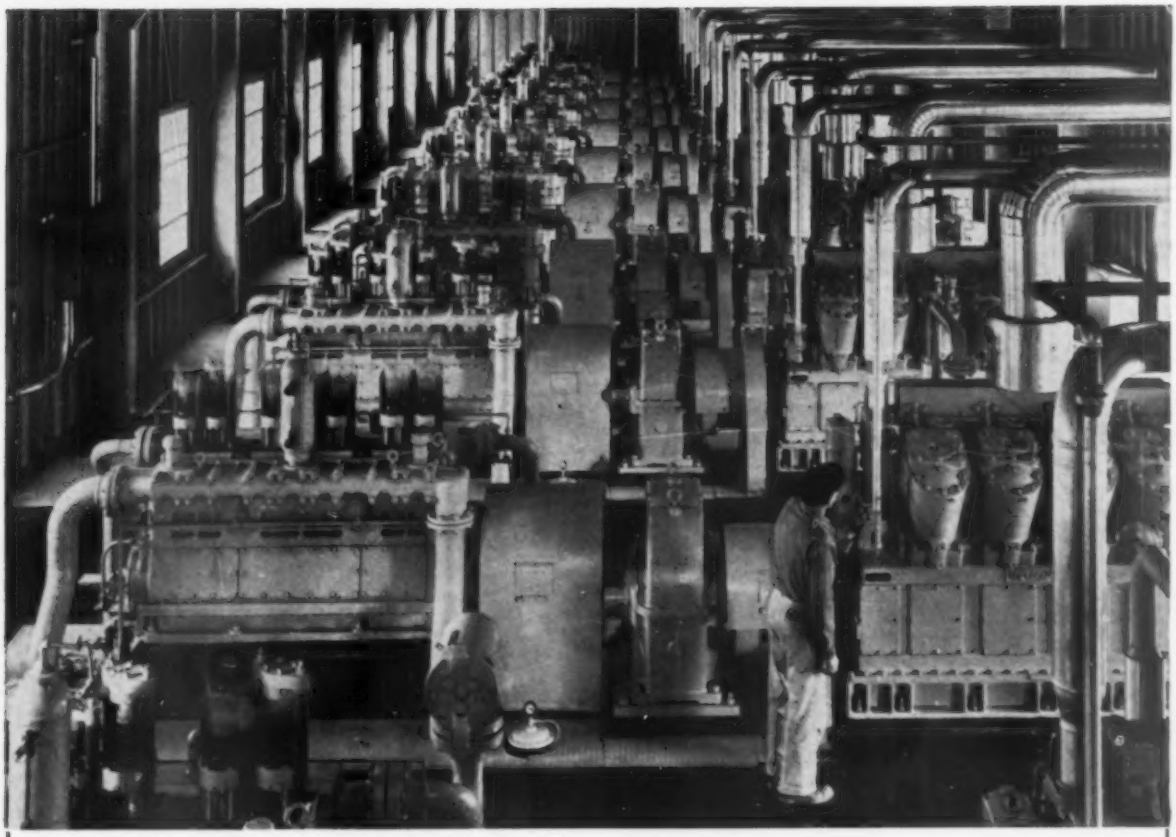


FIG. 9. **For 3½-in. OD tubing** and a bottom-hole pressure of 250 kilograms per sq cm absolute, here is a plot of flow rate in cubic meters per day vs wellhead pressure for various choke sizes and Kh values.



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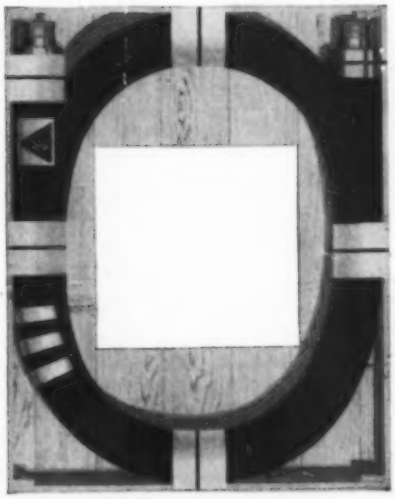

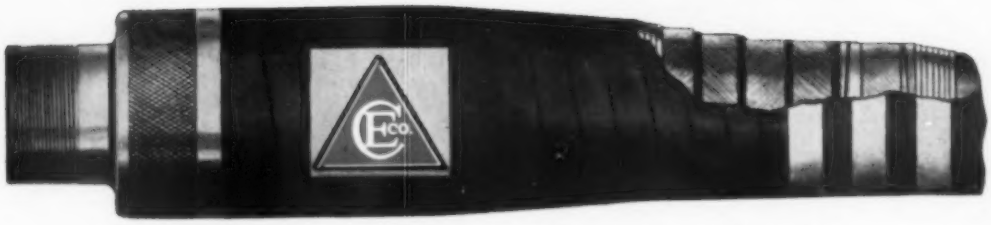

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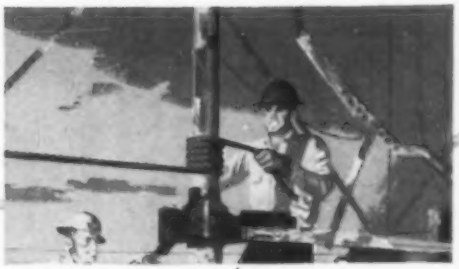

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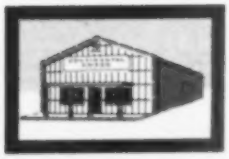

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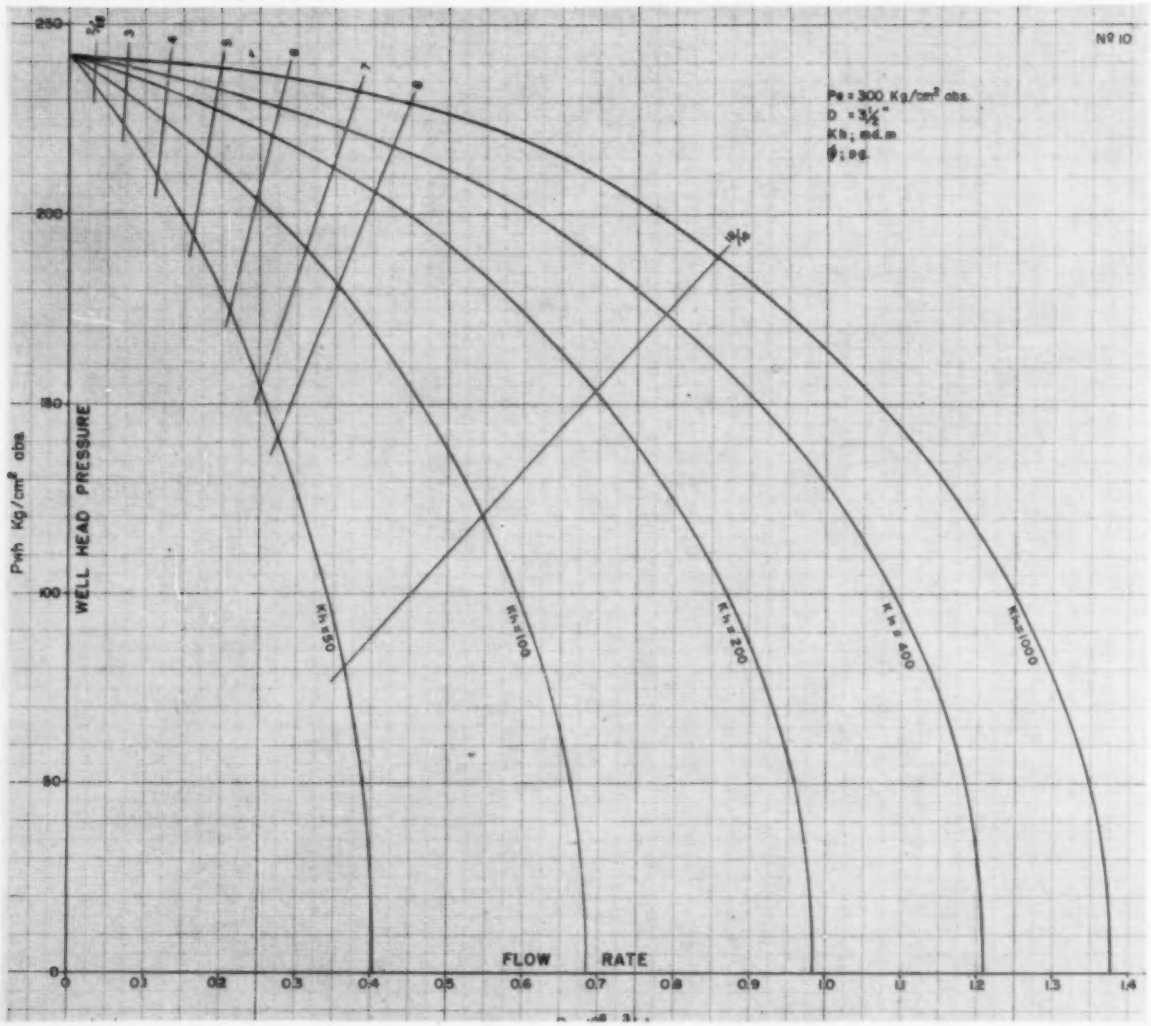

FIG. 10. **Wellhead pressures** vs flow rates where bottom-hole pressure is 300 Kg per sq cm absolute and tubing size is 3½-in. OD for various Kh values and choke sizes.

Squaring both sides of the equation we obtain:

$$\frac{1}{B}Q^2_g + \frac{1}{C}Q_g + (e^s P^2_{wh} - P^2_e) = 0 \quad . \quad (19)$$

Solving Equation 19 for Q_g we obtain:

$$Q_g = -\frac{B}{2C} \pm \sqrt{\left(\frac{B}{2C}\right)^2 + B\,(e^s P^2_{wh} - P^2_e)}$$

(Equation 1 in this paper)

The maximum flow capacity of the tubing is obtained when $P_{wh} = 0$ in Equation 1 (See footnote 5). Therefore, the maximum flow capacity of the tubing is:

$$Q_g = \sqrt{\left(\frac{B}{2C}\right)^2 + BP^2_e} - \frac{B}{2C} \quad . \quad . \quad . \quad . \quad (20)$$

(Footnote No. 5)—This value does not correspond to the absolute open flow potential of the well, since this is defined as the volume rate of flow obtained when the flowing bottom-hole pressure is equal to the atmospheric pressure.

Acknowledgments

The authors wish to express their appreciation to Ingr. A. Barnetche, exploitation manager of Petroleos Mexicanos for granting permission to publish this paper; to Ingrs. J. Hefferan and A. Romero Juarez for their helpful suggestions, and to Ingr. E. de la Torre, Jr., for his help in the translation to English.

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FIG. 1. **From guided missiles to the oil patch?** Corning's new super glass is lighter than aluminum, harder than high carbon steel, and is one of the world's strongest materials for its weight. The white cone is a guided missile radome which has been heat treated. Note the contrast between it and the clear castings yet to be heat treated.

EVER since World War II, authors of mechanical engineering handbooks have been hard pressed to keep their books up to date, what with the new materials coming from our laboratories in a steady stream — leap-frogging one another in both quality and economy. Improved steels, alloys, and plastics have called for frequent alterations of the tables in such books; and at the same time, the quality of end products has zoomed upward as better materials are fed into our manufacturing processes.

One of the great beneficiaries of this enjoyable turmoil has been the oil and gas industry. Better drill pipe, improved pressure vessels, engines and valves have given us deeper holes, cheaper drilling, and the means of producing gas and oil under extreme pressures.

Yet the industry's surging technical advances have created a relentless demand for still better products — offering rich rewards for those that measure up to its needs, oblivion for those that fail.

The most exciting new product to come along in years is a new super glass invented and developed by Dr. Donald Stookey of the Corning Glass Works. It is lighter than aluminum, harder than high carbon steels. It has a flexural strength ranging above 30,000 psi.

As a matter of fact, experimental compositions have registered flexural strengths as high as 60,000 psi, and its ratio of strength to weight is perhaps the world's highest.

Donald M. Taylor
Gulf Coast Editor

TABLE 1. Comparison of Properties.

	PYROCERAM				METALS				
	8605 (opaque)	8606 (opaque)	8607 (clear)	8608 (opaque)	Aluminum (99.0) 2 S alloy annealed	Aluminum 75 S alloy annealed	Gray cast irons	Stainless steel type 302 annealed	Titanium (99.9) iodide tit.
Specific gravity Room temp. (25°C)	2.62	2.60	2.40	2.50	2.71	2.80	7.0 to 7.7	7.93	4.50
THERMAL									
Softening temp.[1] (°F)	2450	2250	—	—	—	—	—	—	—
Specific heat (25°C)	0.185	0.190	—	0.190	0.23 (100°C)	0.23 (100°C)	0.131 (100°C)	0.053 (100°C)	
Mean (25°C-400°C)	0.230	0.232	—	0.240	—	—	—	—	—
Linear coef. of Thermal expansion x 10^7 (25° to 300°C)	14	57	-7	2 to 3	256	232	100 (25°C)	95 (-18 to 316°C)	82
MECHANICAL									
Modulus of elasticity (psi x 10^{-6})	19.8	17.8	—	—	10	10.4	11.6	29	15.9
Poisson's ratio	—	0.24	—	—	0.33	0.33	0.17	—	—
Tensile strength (psi x 10^{-3}) (For metals: Ultimate strength)	—	—	—	—	13	40	20 to 60	80	36
Modulus of rupture (psi x 10^{-3})	37	32	—	—	—	—	—	—	—
M. R. strength spec. gr. (psi x 10^{-3})	14.1	12.3	—	—	4.8	14.3	2.67 to 8.0	10.0	8.0
Hardness									
Knoop 50 GM	1100	940	—	—	—	—	—	—	—
500GM	720	570	—	—	No conv.	No conv.	180-300	147-201	100

NOTE 1
Softening temp. method of evaluation; Pyroceram — comparable to ASTM C 24-46.
NOTE 2
Strength to weight ratio:
(a) Pyroceram, ceramic and glass based on modulus of rupture per specific gravity.
(b) Metal based on tensile strength which is actually ultimate strength.
NOTE 3
Knoop number for metal was obtained by converting Brinell to Knoop number.

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FIG. 2. **Things to come?** Both rod and tubing of various diameters can be made from Pyroceram. Shown here are pieces of the new material in its glassy state (clear) and in its crystalline state after firing. FIG. 3. **Thermal expansion** of the new super glass. FIG. 4. **Modulus of rupture vs temperature.** Flexure tests made at temperature indicated after equalization of specimens. FIG. 5. **Effect of continued high temperature on flexure strength.** Specimens held at temperature indicated for 100 hours under tensile loading of 1000 psi then tested at room temperature.

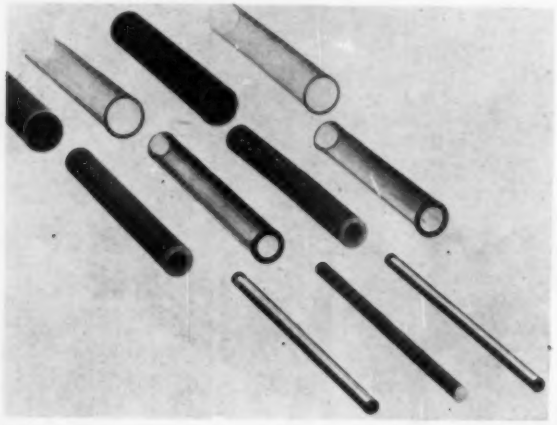

FIG. 2

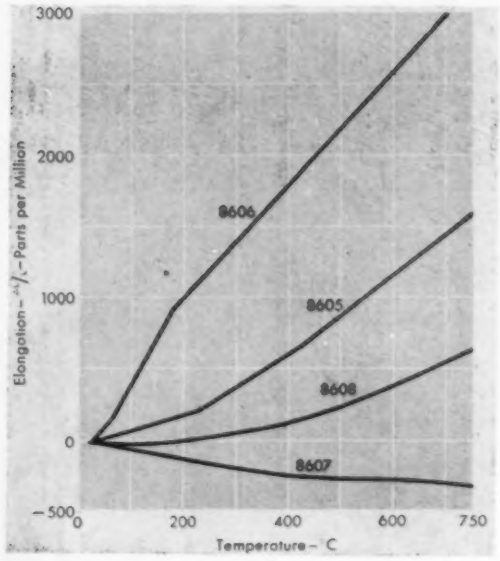

FIG. 3

The new material which has been named Pyroceram, is a crystalline form of ordinary glass. It is made by melting a glass batch containing one or more nucleating agents, forming and cooling it by usual methods. The casting is then heat treated, and during this process, the nucleating agents form billions of sub-microscopic crystallites per cubic millimeter. As the heat continues, each of these crystallites acts as the center of crystal growth.

After the heat treatment, the product is a fine-grained crystalline material, non-porous and harder than most ceramics and many metals. It has unusual thermal characteristics, retaining virtually all its strength up to 1300 F or so. By varying the manufacturing process, the thermal expansion of the material can be varied from slightly negative to 200 × 10^{-7} per deg C.

This super glass is actually an entire family of new materials. Dr. William H. Armistead, Corning vice president in charge of research and development, stated that the company has made more than 400 different compositions of this new glass, and only a fraction of these have been fully tested.

The Table I shows how the new material stacks up with a number of our metal products:

The Table I shows how the new material can be formed by any means used in forming ordinary glass. It lends itself to *blowing, pressing* and sheet glass, tubing and rod can be formed by *drawing* the molten glass from a melting tank. But most important of all, the glass is very fluid in its molten

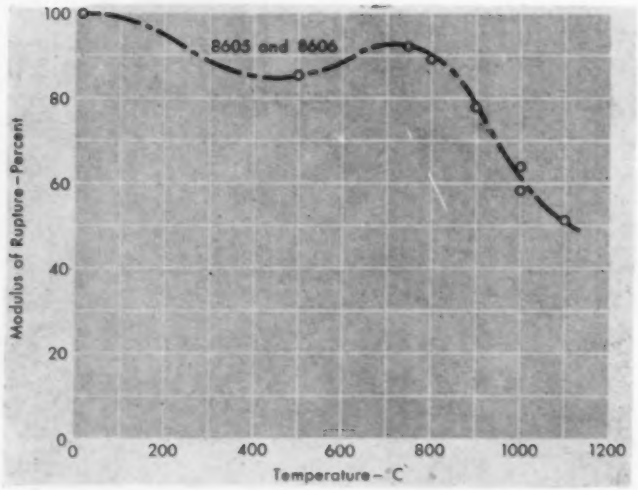

FIG. 4

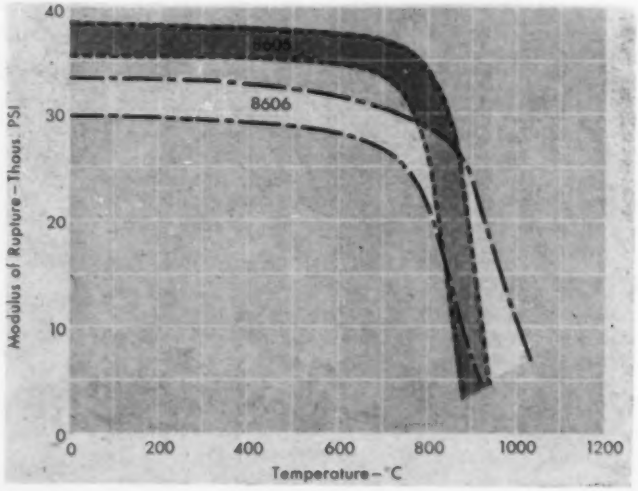

FIG. 5

state and can be formed by centrifugal and investment casting.

Mechanical properties. While there are hundreds of pyroceram compositions yet untested, (and perhaps hundreds more not yet discovered) there are four types that have been thoroughly investigated to date. Pyroceram Code 8605 is the strongest (although experimental compositions have been tested at much higher flexural strengths). This particular composition has a specific gravity of 2.62 and a modulus of rupture of 37,000 psi. It loses little of this strength at temperatures up to 1300 F (see Fig. 5).

It's strength is relatively unaffected by surface scratches, which incidentally are somewhat difficult to come by. For instance, the Code 8605 cannot be measured by Brinell or Rockwell machines, and comparable diamond indentation tests have shown that the product is harder than flint, granite and hardened high carbon steel (65 Rockwell C). Its hardness is less than that of sapphire.

The crystalline structure of the material is such that it has high resistance to abrasion. Also, the material is nonporous and gas tight.

Electrical properties. The electrical insulating properties are excellent: Its high frequency dielectric strength compares favorably with those of the best electrical ceramics. At a frequency of 10^{10} cycles per second Pyroceram Code 8605 has a loss factor of 0.0022 at room temperature and 0.013 at 930 F.

Thermal properties. The thermal properties of the new product can be tailored to suit almost any need. In fact, the composition and treatment can be varied, so that this new glass will actually shrink as it is heated. See Fig. 3 for thermal expansion properties of four types of the new material.

Because of its low thermal expansion and high strength it is extremely resistant to thermal shock.

Chemical properties. Although long term chemical tests have not been completed, early indications show that Codes 8607 and 8608 are nearly as resistant to acid attack as Pyrex glass. They exceed the latter in resistance to alkali attack.

Optical properties. This property varies with composition. By controlling the heat treatment, Code 8607 may be made transparent in its crystalline form; Code 8608 may be translucent or, upon further firing, a pure white opaque material. Codes 8605 and 8606 are white opaque in their crystalline form.

Cost. William C. Decker, president of Corning, says there's insufficient cost data to accurately forecast the price. However, he predicts the cost will be higher than that of glass, yet much lower than many of the metal alloys and steels now in use. He points out that Pyroceram has two substantial cost advantages: (1) Batch materials going into the product are not costly, and (2) it can be shaped while molten by regular glassmaking processes.

Possible applications. Possible applications of the new material can be determined from its properties, according to Corning's president. "It is obvious," he says, "that Pyroceram — a light, tough, hard, temperature resistant material at relatively low cost—should have a number of important uses."

Following this line of reasoning, it is easy to foresee many applications in the oil industry. Pressure vessels and piping which are subjected to corrosive products will obviously comprise a portion of the market. At least one oilfield supply company is planning to produce pressure vessels made of the new material in the near future according to one of its officials.

Other applications are likely to be found in drilling and producing operations both on land and offshore. In fact, possible uses are innumerable, ranging all the way from engine parts to piping. ★ ★ ★

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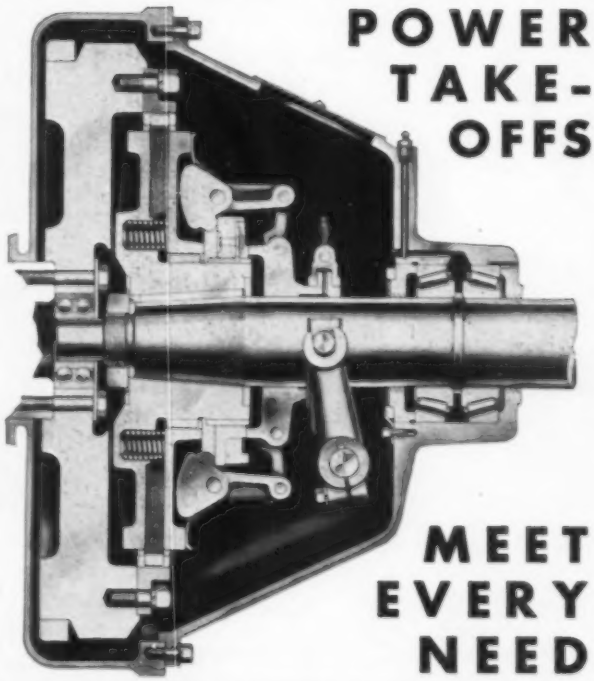

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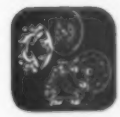
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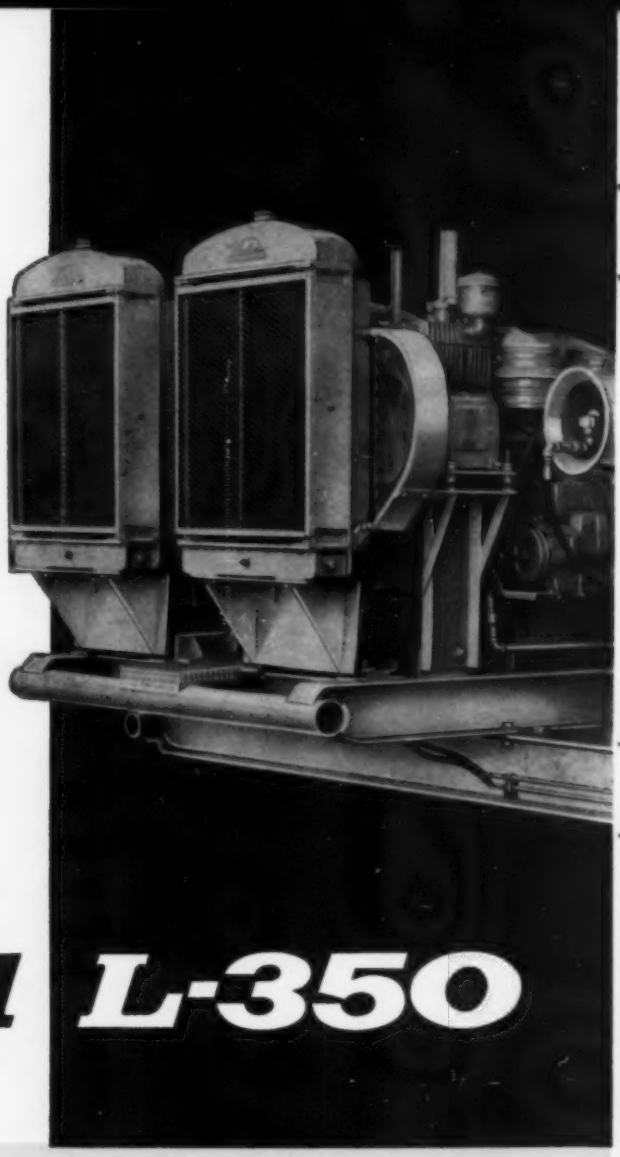

The new Cardwell L-350 is a compact single or twin engine draw works using plate frame construction to achieve a high strength-to-weight ratio. All drives are oil bath lubricated for longer chain life. Here's an extremely versatile unit that is readily adaptable to various trailer mountings as well as conventional skid masts. Single lever controls are centralized in a forward mounted control panel. The safety factor is increased by allowing the driller full view of all drilling operations. An optional sand line drum is offered that does not require any main frame changes. The Model L-350 has a nominal horsepower rating of 350.

Job-tailored Features

- PLATE-FRAME CONSTRUCTION for high strength-to-weight ratio.
- CHAIN DRIVES—all oil bath lubricated.
- SIMPLIFIED SINGLE LEVER CONTROLS for safe, convenient operation.
- FRICTION CLUTCHES — Fawick's newest design — exterior mounted.
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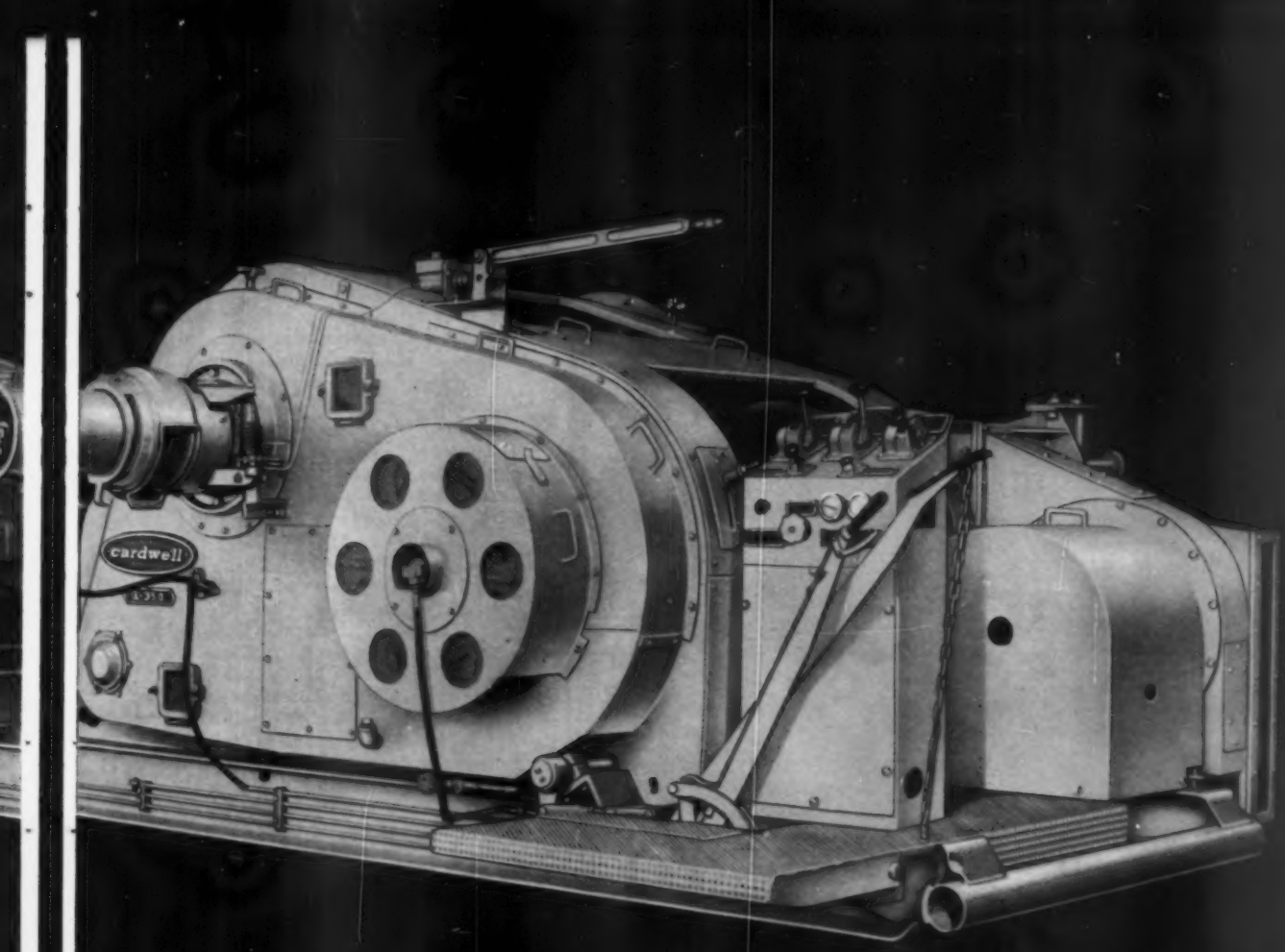

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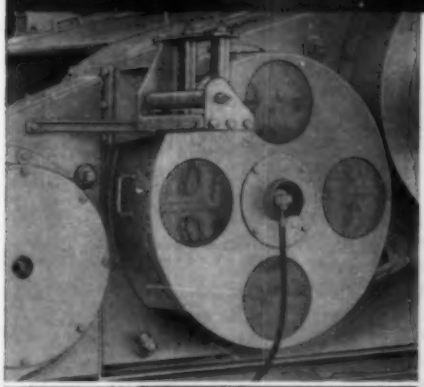

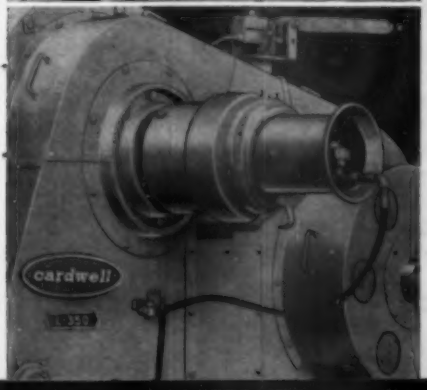

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In the Parks Pennsylvanian field of Midland County, West Texas

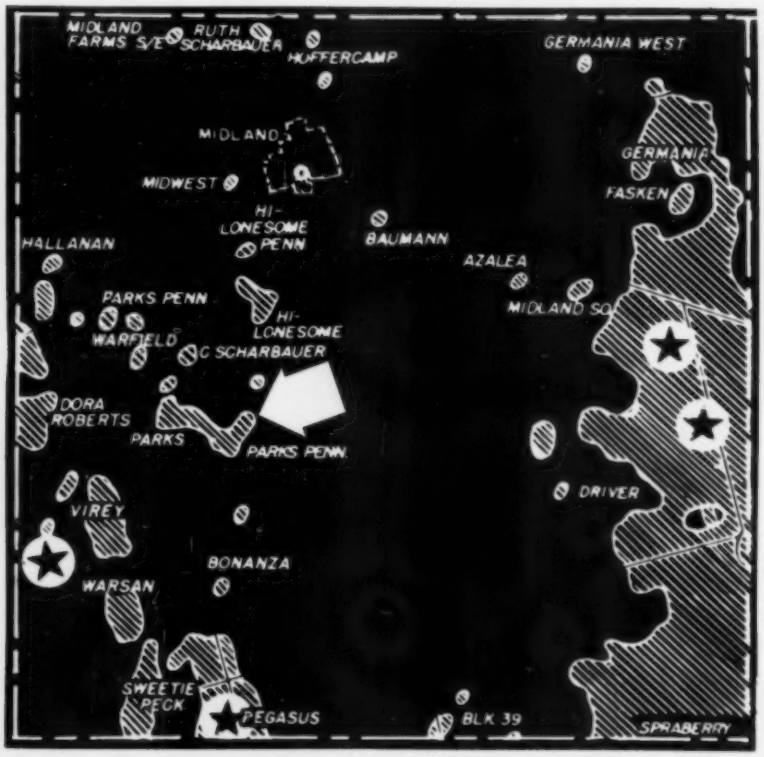

FIG. 1. **Location of big miscible displacement project** is in the Parks Pennsylvanian field south of Midland, in West Texas. Arrow indicates field; black stars on white circles show location of natural gasoline plants in area.

Magnolia Plans Big Miscible Displacement Recovery Project

Ultimate recovery estimated at 100 to 150 percent over primary recovery by injection of over 1½ million bbl of propane during a nine-month period in 25 injection wells

ONE of the largest miscible-phase displacement recovery projects yet proposed is slated to get underway shortly by Magnolia Petroleum Company in its Parks Pennsylvanian unit in Midland County, Texas. The unit involves 8160 acres, over 5000 of which are productive. Although Magnolia is the principle lease holder and has been designated as operator, other operators are: Brook Oil Corporation, Cuban American Oil Company, Sunray Mid-Continent Oil Company, The Texas Company and Tidewater Oil Company. Tentative approval was granted recently by the Texas Railroad Commission, and injection of 2000 bbl of propane per day was started the first of June 1957.

The plan calls for injecting over 1½ million bbl of propane into 25 injection wells at the rate of 6000 bbl per day over a period of about nine months. After the propane has been displaced into the reservoir, it will be followed by gas injection. Calculations indicated that about 16 million cu ft of gas daily will be required to maintain the miscible-phase displacement process. It is conservatively estimated that ultimate oil recovery will be increased about 100 to 150 percent of the calculated primary recovery. Total cost of the miscible displacement project is estimated to be about $3½ million.

Magnolia will take some 2000 bbl of propane per day from its Pegasus natural gasoline plant about 15 miles to the south, and once the project gets under way, will take an additional 4000 bbl of propane daily from the Midkiff area in the Spraberry trend about 23 miles to the east. When in full swing, average propane injection in each of the 25 injection wells will be about 240 bbl per day. Wellhead injection pressures in the initial stage are not expected to be very high, but will be well above the vapor pressure of propane at the anticipated temperatures. Bottom-hole pressure is about 1700 psi and the average well depth is approximately 10,400 ft. So, the hydrostatic pressure of the column of propane is more than adequate to overcome the average reservoir pressure.

What is miscible displacement? In the primary recovery of oil, and especially where dissolved gas accounts for the driving mechanism, a large percentage of the oil is trapped in the tiny pore spaces within the reservoir. The capillary pressure tends to hold the liquid oil in the minute cavities in much the same way water is held in a sponge.

Waterflooding has proved a successful and economical means of "pushing" this entrapped oil out of the reservoir, and has permitted recoveries of as much as 50 percent of the oil originally in place. Even with this successful

method of oil recovery, over half the oil is left in the reservoir, trapped in the minute pore spaces by capillary pressure that the "pushing" water could not overcome. Considerably more oil could be recovered if this capillary pressure could be reduced so that the "pushing" mechanism would act more efficiently. It was found in the research laboratories that if the "pushing" mechanism was miscible with . . . that is, soluble in . . . the reservoir fluids, that the capillary pressure would be negligible. Of course, there will always be parts of the reservoir not swept by the "pushing" bank, and this reduces the sweep efficiency.

Since propane is highly soluble or miscible in oil, it is an ideal material to make up the pushing bank or "slug." It acts as a washing solution. The front of the slug will contain a high concentration of the reservoir oil, and this concentration diminishing toward the back of this slug.

The propane costs almost as much as a barrel of crude oil, so it would not be economical to completely flood the reservoir with propane just to recover the oil. To maintain the displacement process and keep the propane bank moving toward producing wells, gas is injected behind the propane slug. This is much more economical, and since the natural gas is highly miscible in the propane, the gas sweeps the propane through the reservoir. The gas also maintains adequate reservoir pressure, and the entire process makes for a very efficient method of recovering very high percentages of oil originally in the reservoir.

History of Parks Pennsylvanian

The field was discovered December 6, 1950, with the completion of Magnolia's H. F. Timmerman No. 1. Development continued at a uniform rate until August 1955. As of April 1, 1957, there were 55 producing wells in the field.

Geology. The Parks Pennsylvanian field produces from the Bend limestone reservoir. It is an anticlinal structure faulted from northwest to southeast as shown in Fig. 2. Average well depth from surface is about 10,400 ft, and the oil-water contact is at −7791 ft subsea. There is no gas cap, and the estimated average net pay thickness is from 20 to 25 ft, and gross thickness ranges from 75 to 85 ft.

Reservoir properties. Initial reservoir pressure was measured at 4567 psig at a datum of 7600 ft subsea. In January 1957, it was measured at 1710 psi. Fluid behavior analysis indicates that the saturation pressure is 3508 psig, and the solution gas-oil ratio was

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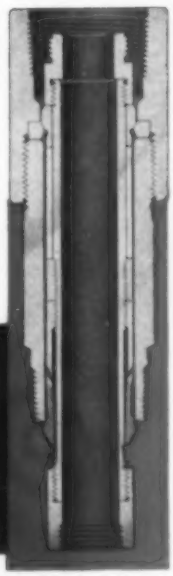

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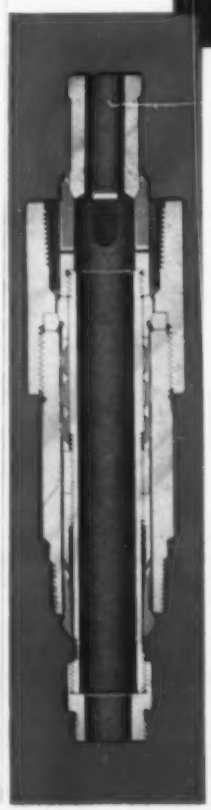

If at any time the Stainless Sealing Ring Seat, which is part of the Tubing Assembly, should become damaged or leak, an effective seal can be obtained without pulling tubing. The Rod Assembly is engineered and designed so that by replacing the Spacer Ring on the Hold-Down Lock Body with three Ring Type Seating Cups, the seal is transferred to the Seat Support Nipple with the Sealing Ring and Sealing Ring Seat serving as a No-Go ring and supporting the load.

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Fluid properties. Average API gravity of produced oil is 44.5 deg at 60 F, while the average gravity of the produced gas is 0.81. The formation volume factor at the bubble point is 2.067. Oil viscosity at the bubble point is 0.22 cp and at atmospheric pressure and reservoir temperature is 1090 cp.

Statistical data. Cumulative oil production from the unit up to April 1, 1957, was 3,362,820 bbl, while daily oil production for the month of March 1957, was 985 bbl per producing day. Water production was only 17 bbl per day. Daily gas production was 9.5 million cu ft, and the gas-oil ratio averaged 9680. This production came from 40 flowing and 14 artificial lift wells. As of March 1957, the number and classification of wells in the field were:

Top allowable	1
High gas-oil ratio	22
Limited capacity	30
Marginal	1
Injection wells (water)	4
Off production	1
Total	59

Pilot water flood. Reservoir performance data indicates that the reservoir is operating under a solution gas drive. In order to increase oil recovery, the Parks Pennsylvanian unit was formed effective August 1, 1954, and a pilot water injection program initiated February 24, 1955. Water injection has been in four wells as indicated in Fig. 2. They were so chosen as to form roughly a 147-acre five-spot pattern. In addition to the well in the center of the five-spot, the performance of nine adjacent producers has been carefully observed as shown on Fig. 4.

Initial water injection rates were in the neighborhood of 2400 bbl per day about equally apportioned between the four injection wells. Since that time, injection rates have been varied, and at present, about 2450 bbl per day are being injected. It is anticipated that the waterflood project will be continued concurrent with the miscible-phase displacement project. As of April 1, 1957, cumulative water injection stood at 1,639,000 bbl for an overall injection rate of about 2150 bbl daily. Present injection pressure is 1200 psig at the surface and all wells are injecting at full capacity for this pressure.

As was to be expected, water injection did not immediately reverse the trend of the decline for the pilot area.

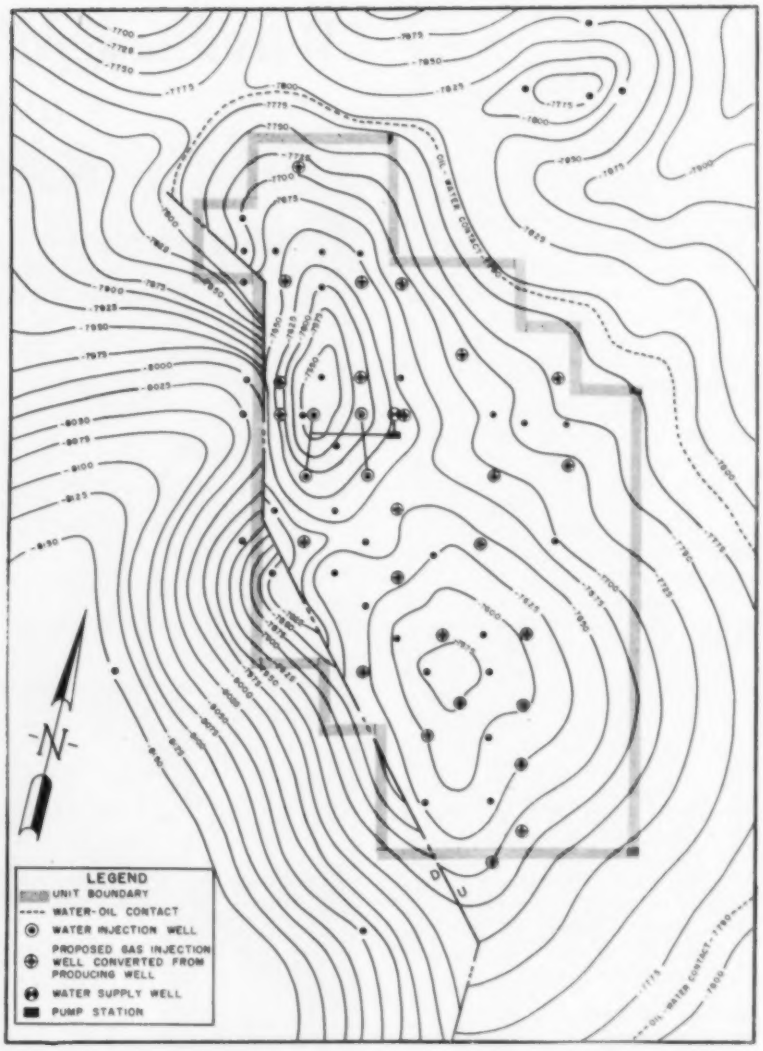

FIG. 2. **Bend Pennsylvanian limestone reservoir** showing location of field-length fault, boundary of unit, water injection wells and proposed gas injection wells to be converted from present producing wells.

During the period February 1955, to December 1955, the allowable and bottom-hole pressure of the center well of the five-spot continued to decline, although the month-to-month increase in gas-oil ratio had been arrested in July 1955. Likewise, for the entire 10 wells in the pilot observation area, the allowable declined through October 1955, and the bottom-hole pressure decreased until March 1956, with the gas-oil ratio increase stopped by July 1955.

In February 1956, the center well of the five-spot was given a 20-bbl per day increase. Since that time, its allowable has been further increased, and allowable increases were also obtained on seven of the remaining nine wells in the pilot area. At present, the center well of the five-spot has an allowable of 210 bbl per producing day, as compared to the minimum allowable in the field of 44 bbl per producing day. Present allowable for the 10 producing wells in the pilot observation area is 926 bbl per producing day as compared to the minimum allowable of 319 bbl per day, an increase of 195 percent.

Only one injection well, Parks field unit No. 10-1, has produced any water since injection started. Prior to April 1, 1957, when this well's allowable was cut back from 210 bbl per producing day to 106 bbl per day, the well produced about five barrels of water daily. Since the allowable cut back, no water production has been noted. The center well of the five-spot has not yet shown any water production. From this per-

formance data, it is apparent that premature water breakthrough has not yet occurred. It is believed that the above results of the pilot water injection area establishes the feasibility of fluid injection into the Blend Pennsylvanian reservoir.

Proposed Miscible Displacement Program

Although the pilot water flood has indicated that water injection will yield increased oil recovery, it is believed that miscible-phase displacement will result in appreciably more recovery than waterflooding.

Miscible-phase displacement is a new concept in oil recovery by pressure maintenance or secondary recovery methods. No field has yet been depleted by this process to the point of making it possible to evaluate the technique from actual field performance. However, laboratory data which have been reported in technical publications indicate higher ultimate recovery due to a reduction in residual oil saturation in the reservoir after the flood front has passed. It is anticipated that the proposed miscible displacement program will recover an additional 100 to 150 percent of the ultimate primary recovery.

The liquefied petroleum gas and natural gas will be injected into 25 wells whose locations are indicated in Fig. 2. The LPG slug will become miscible with the Parks Pennsylvanian crude oil at the front of the propane bank, while the driving gas phase will become miscible with the LPG behind the bank. The miscible slug has a driving as well as a solvent action on the displacement reservoir oil, resulting in a lower residual oil saturation and thus less unrecoverable oil. Temporary approval by the Texas Railroad Commission was granted in order to start propane injection immediately while the reservoir pressure was sufficiently high to assure miscibility.

Field rules requested. New field rules for the Parks Pennsylvanian unit were requested in order to transfer allowables and thereby control the sweep pattern of the propane front within the reservoir. Included in the request also was granting credit of 1000 cu ft of gas for each barrel of injected propane against total produced gas.

Acknowledgment

Information contained in this paper was extracted from material submitted as applicant's exhibits before the May 28, 1957 hearing of the Texas Railroad Commission at Austin, Texas, which exhibits were made available through the courtesy of Magnolia Petroleum Company, Dallas, Texas. ★ ★ ★

Fig. 3 and 4 on Page B-90

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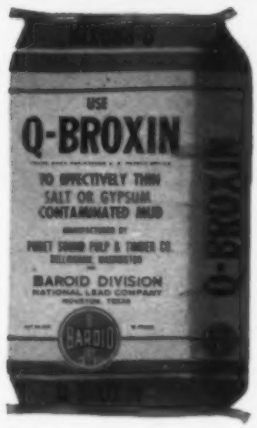

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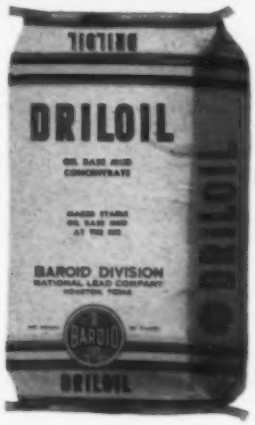

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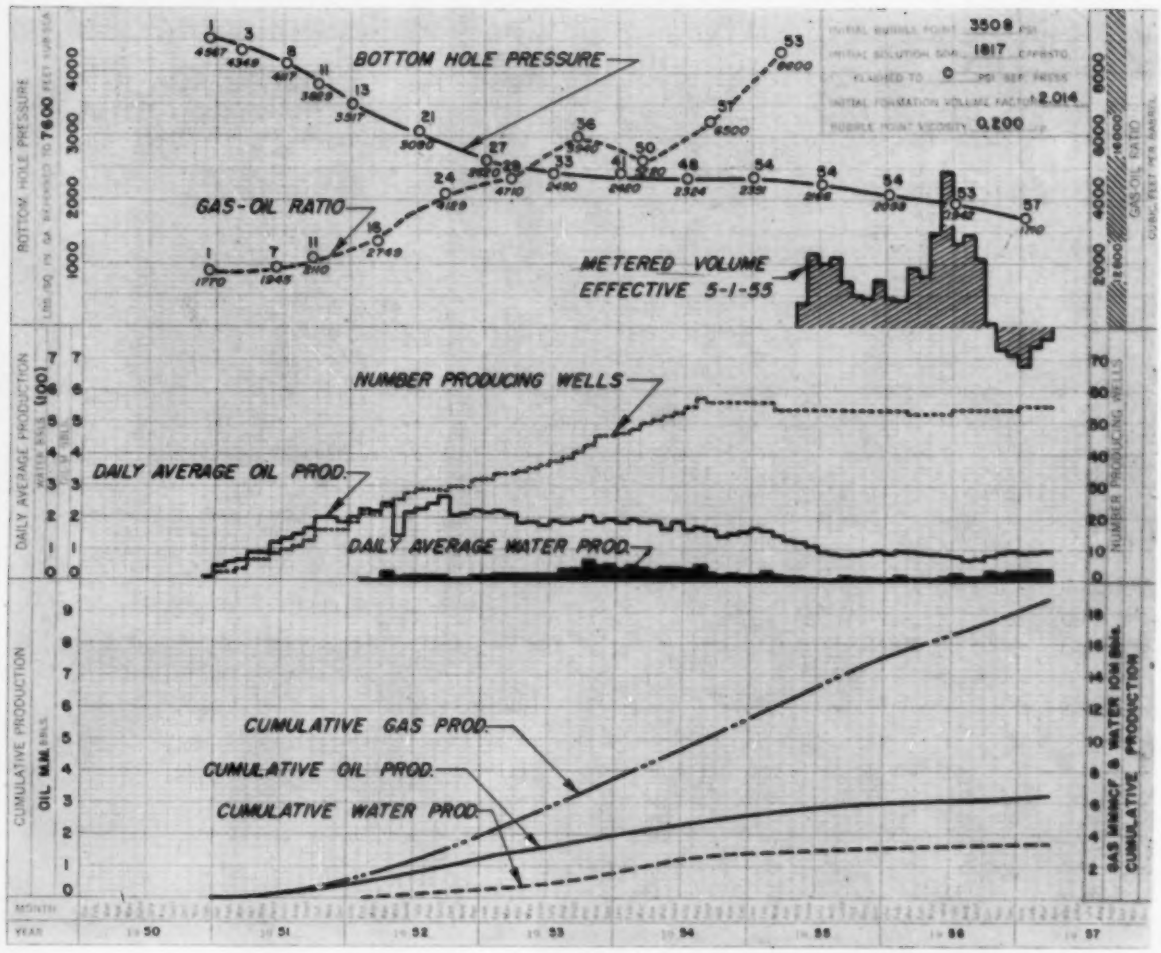


FIG. 3. **Field performance** of the Parks Pennsylvanian unit since discovery date of December 6, 1950.

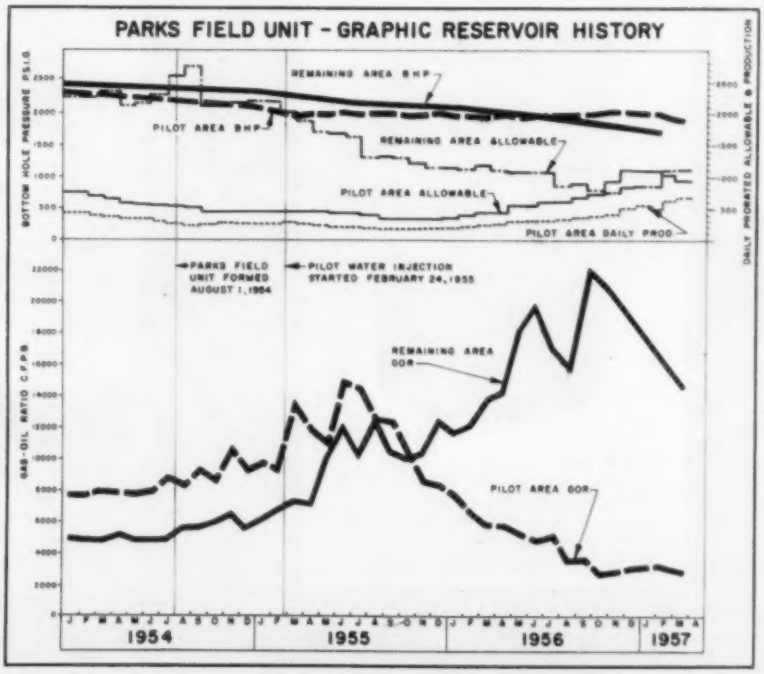
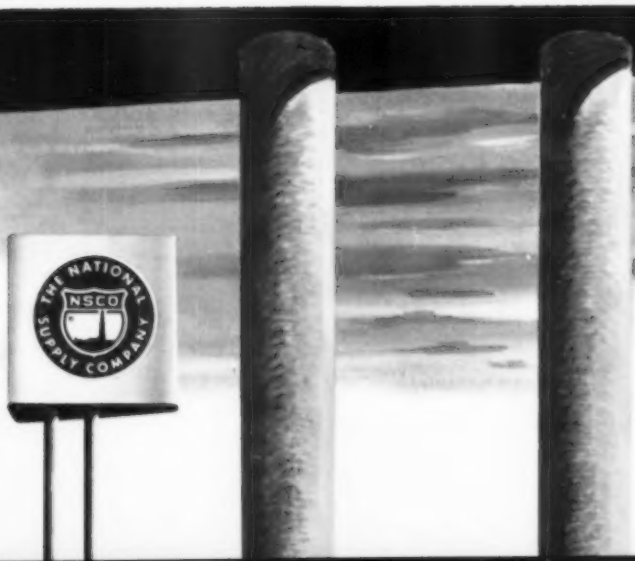


FIG. 4. **Feasibility of fluid injection** is indicated by this graphic history of the Parks field unit showing the relative performance of the pilot waterflood area in relation to the remainder of the unit. Note significant drop in gas-oil ratio in pilot area.



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Continued on next page

Continued from preceding page

More important, they are carefully arranged in bins, counters and warehouse areas to allow you to *see*, *select*, *compare* and *decide on* before you purchase.

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Today's National Supply Stores are geared to give you a new high level of fast, modern service. Why not learn about the many answers they may have for your operating problems—by personally shopping at the National Supply Store the next time you are in town.

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Safe table guard—With a wide, non-skid tread top of original National design. Removable guard extends above table top, deflects all mud.

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These features, plus the confidence of contractors everywhere, are good reasons why you buy wisely when you choose a National Rotary. You'll operate more efficiently with a National Rig behind it, too!

Whether you need a "heavyweight" like the model shown or a "lightweight" for shallow hole, the complete line of National Rotaries can effectively meet your requirements. (See the new SA-175 National Rotary on the next page.)

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See next page for National Kellys and Collars

...and reduce

drill pipe failures with

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Both National Kellys and Drill Collars are readily available in all standard A.P.I. joint sizes. See your National representative soon about the types and sizes to meet your needs!

In operation with this National Kelly is the SA-175, first of a new line of National Rotaries. It features a rectangular design for easy installation, a cartridge-type pinion shaft assembly, and a unitized table and bearing assembly.

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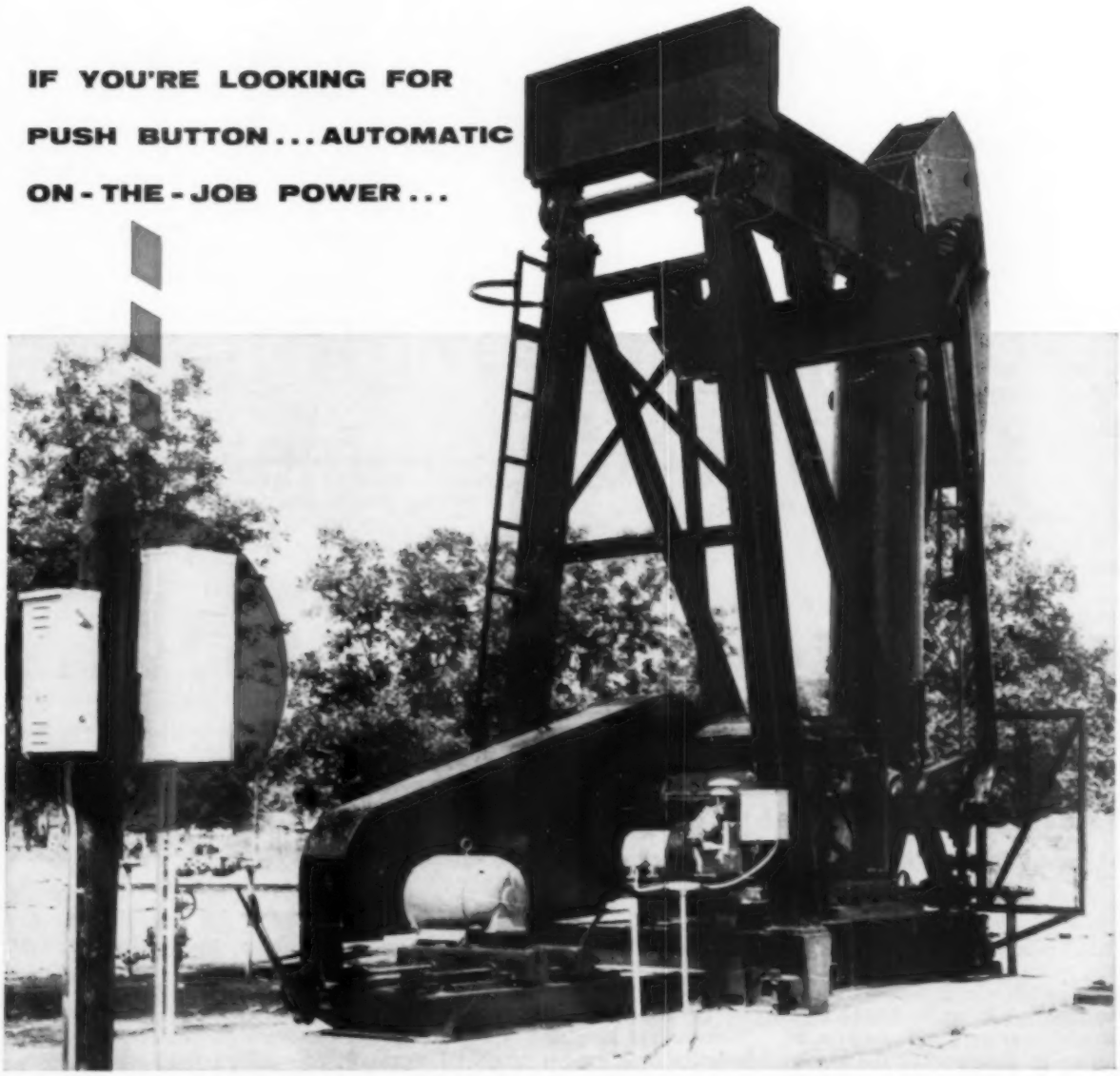

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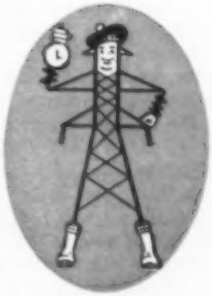

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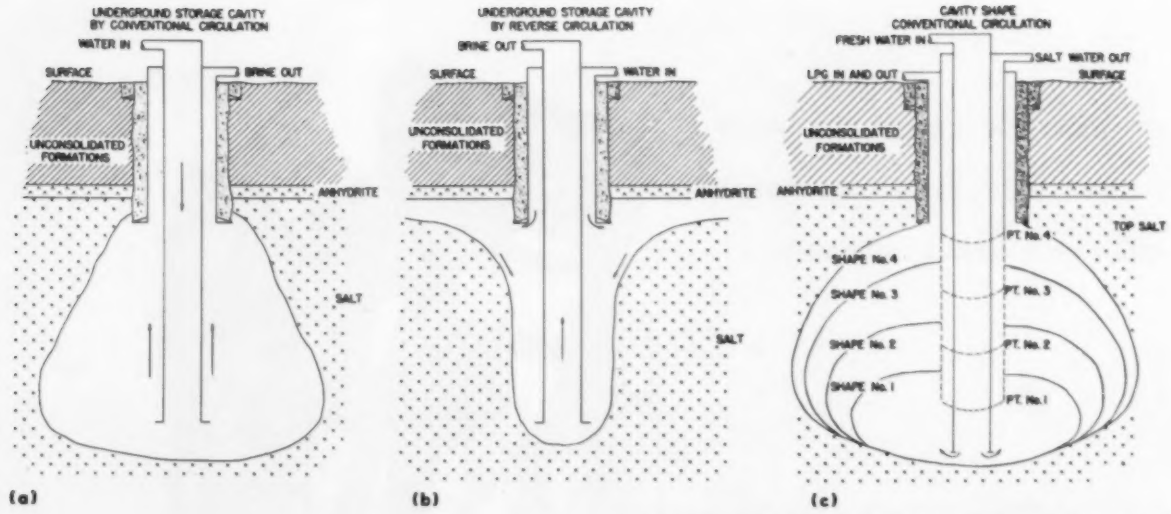

FIG. 1. **Three Methods of Developing Cavities (a)** Conventional bottom injection method **(b)** reverse circulation technique **(c)** progression technique where by wash pipe is moved to control cavity shape.

D. F. Jahns,
Shell Oil Company
Midland, Texas

Formation Strength In Salt Cavern Storage

To anticipate volumes of LP gas that may be safely stored, formation strengths and cavity shape factors must be determined

SALT is one of our oldest known and most common minerals. It has played an important part in history throughout thousands of years, has been the cause of many wars, and a factor in the shaping of governments. The average person requires from five to 12 lb of salt per year. Of the vast amount of salt required in our everyday life, only five percent is used in the home; the remainder is used in industry.

Among the recent innovations in the use of salt is the development of cavities in salt formations for underground storage of LPG. In Gulf Coast salt domes and in bedded salt formations of the Permian Basin, salt "jugs" are developed by drilling a well into the salt section, casing the hole to the salt cap or some distance into the salt section and tubing the well through the open hole section to bottom. Thereafter, fresh water is circulated to leach the salt cavity. Methods for development of an underground salt cavity include: 1. The conventional or bottom injection method illustrated in Fig. 1(a) whereby fresh water is introduced into the cavity at the bottom of the hole. 2. The reverse circulation or top injection method whereby fresh water is introduced into the salt cavity at the top of the cavity (see Fig. 1(b)).

Through the use of an additional string of casing or wash pipe, as depicted in Fig. 1(c), variations to both conventional and reverse circulation may be made to alter the resultant shape obtained through method of circulation.

Some of the advantages and disadvantages of the two methods of circulation are as follows:

Reverse circulation

- A high rate of circulation is obtainable while maintaining highly saturated effluent.
- Near optimum use of fresh water is obtained.
- More rapid development of the salt cavity is possible.
- Can be performed with LPG in the cavity.

Disadvantages include:

- Undesirable cavity shape is obtained.
- Cavings frequently cause plugging while circulating by this method.

Conventional circulation

Most desirable shape of cavity is obtained.

- Minimum operating cost during development.
- Cavings do not affect circulation rate.

Disadvantages include:

- A lower washing rate obtained.
- Lower efficiency from fresh water used.

Various methods have been used for the determination of salt volumes removed through the injection of fresh water into a salt cavity and the recovery of salt water; however, it is beyond the scope of this paper to discuss such determinations. Our interest is con-

From paper, formation strength considerations in Salt Cavern construction and operation presented February 22, 1957 before the Natural Gasoline Association of America at Midland, Texas.

Adomite® gives least fluid loss at bottom hole conditions

Many fracturing additives show desired fluid loss control at surface conditions of low pressure and atmospheric temperature. But at bottom hole conditions, fluid loss becomes so high that effectiveness is lost. Fluid loss control tests demonstrate how effective and profitable Adomite is downhole—in marked contrast with other fluid loss additives.

Compare the deep-down effectiveness of Adomite with other loss control additives

	Fluid Loss at Surface Conditions—100 psi,* 75° F., cc/30 min.	Fluid Loss at Bottom Hole Conditions—1000 psi, 150° F., cc/30 min.
ADOMITE + crude oil	**2.2**	**22.0**
Additive X + crude oil	**37.8**	**Infinite**
Additive Y + crude oil	**8.5**	**Infinite**
Additive Z + crude oil	**13.0**	**295 (1 min., 50 sec.)**

*(Standard API Code 29 Test)

Adomite, when mixed with oil, disintegrates into millions of tiny particles. These particles seal the face of the formation and keep the fracturing fluid from filtering in. Temporarily sealing the formation, Adomite particles do not plug it.

Additives X, Y and Z contain small sealing particles, too. As temperatures increase, however, their particles soften or dissolve. Thus, the effect in controlling fluid loss is greatly reduced, especially at high pressures prevalent under bottom hole conditions.

Straight lease crude, gelled crude or refined oil, treated with Adomite, gives effective fluid loss control at bottom hole temperatures and pressures.

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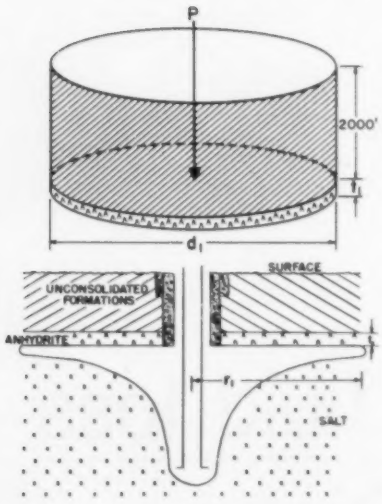


Shear Stress, $S_s = \frac{\text{LOAD}}{\text{AREA IN SHEAR}}$

$S_s = \frac{P}{\text{CIRCUMFERENCE} \times \text{THICKNESS}}$

$S_s = \frac{1\text{psi/ft} \times 2000' \times \pi r_1^2}{\pi \times 200 \times 10}$

$S_s = (100)^2 = 10{,}000\text{ psi}$

$t_1 = 10'$

$d_1 = 200'$

(If $t_1 = 50'$, then $S_s = 2000$ psi)

FIG. 2. Shear stress in reverse circulation type cavity. Large, relatively flat roof reduces potential volume of cavity.

cerned with the shape of leached cavities and determination of maximum size.

Can a Salt Cavern Limit be Established?

The acid industry, as well as others, have brine wells in salt cavities exceeding 1,000,000 bbl in cavern volume. If such a cavity fails, as several have, no danger to surface facilities exists. Such is not the case when LPG is stored in a salt cavern. Collapse, fracture or leakage may result in serious hazards to surface facilities in the surrounding area. It is even possible for the LPG to migrate through an upper porous and permeable formation and appear at the surface some distance from the storage cavity. Explosion or fire hazards therefore may exist with little or no prior knowledge of danger.

Phenomenal growth of the LPG industry has been due, in part, to the availability of adequate storage facilities. Underground storage caverns have provided a large portion of these facilities. To preclude hazards in underground storage, it behooves the industry to exercise all reasonable precautions. NGAA standards cover some of the necessary precautions. Each cavity should be given attention with regard to engineering design, including consideration for:

1. The cavity cap section—its thickness and physical properties.
2. The shape of a cavity—the method of circulation during development.
3. The method of LPG recovery used.

Literature[1,2,3,4] indicates that practical physical tests can be made to aid in determining design limitations. A specific safe limit is virtually impossible to calculate due to the many unknowns. "Perfection in nature is rare" — inhomogeneity of rock through geological processes confronts the investigator of rock strengths with such variables as fracturing, jointing, seams and faults. These conditions may exist superjacent to or within a salt cavity without our knowledge; therefore, design safety factors must be selected which will account for any anomalous conditions affecting the strength of the cavity section. Core samples of the cap and salt sections can be used to obtain physical properties.

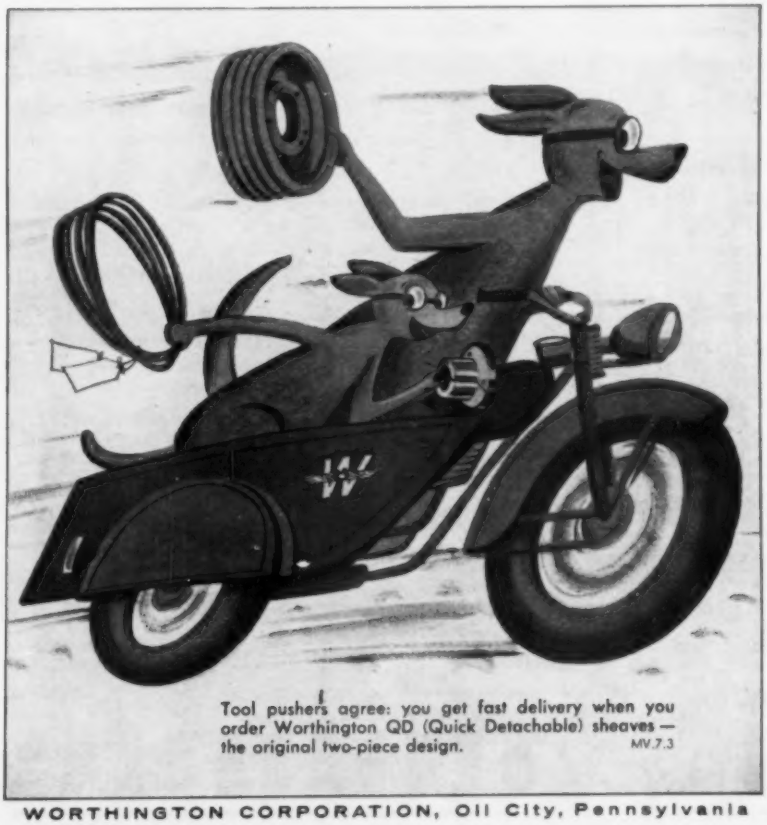
Some data is available from the Bureau of Mines work; however, little information is available for anhydrite and salt which are of interest here. Anhydrite and salt both vary markedly in their physical porperties from one location to another. Most accurate physical properties data are obtained by testing cores from the cavity location. Salt cores and anhydrite cores from West Texas locations, at approximately 2000 ft in depth, have been tested under unconfined conditions, and confined conditions, including triaxial testing. Ultimate compressive strength, unconfined, was found to be within the following range:

Salt — 2600 to 4000 psi
Anhydrite — 4500 to 23,000 psi

Ultimate compressive strength, confined,[5] was found to be:

Salt — 17,000 psi @ 2000 atmospheres and 150 C

Anhydrite — 82,000 psi @ 2000 atmospheres and 150 C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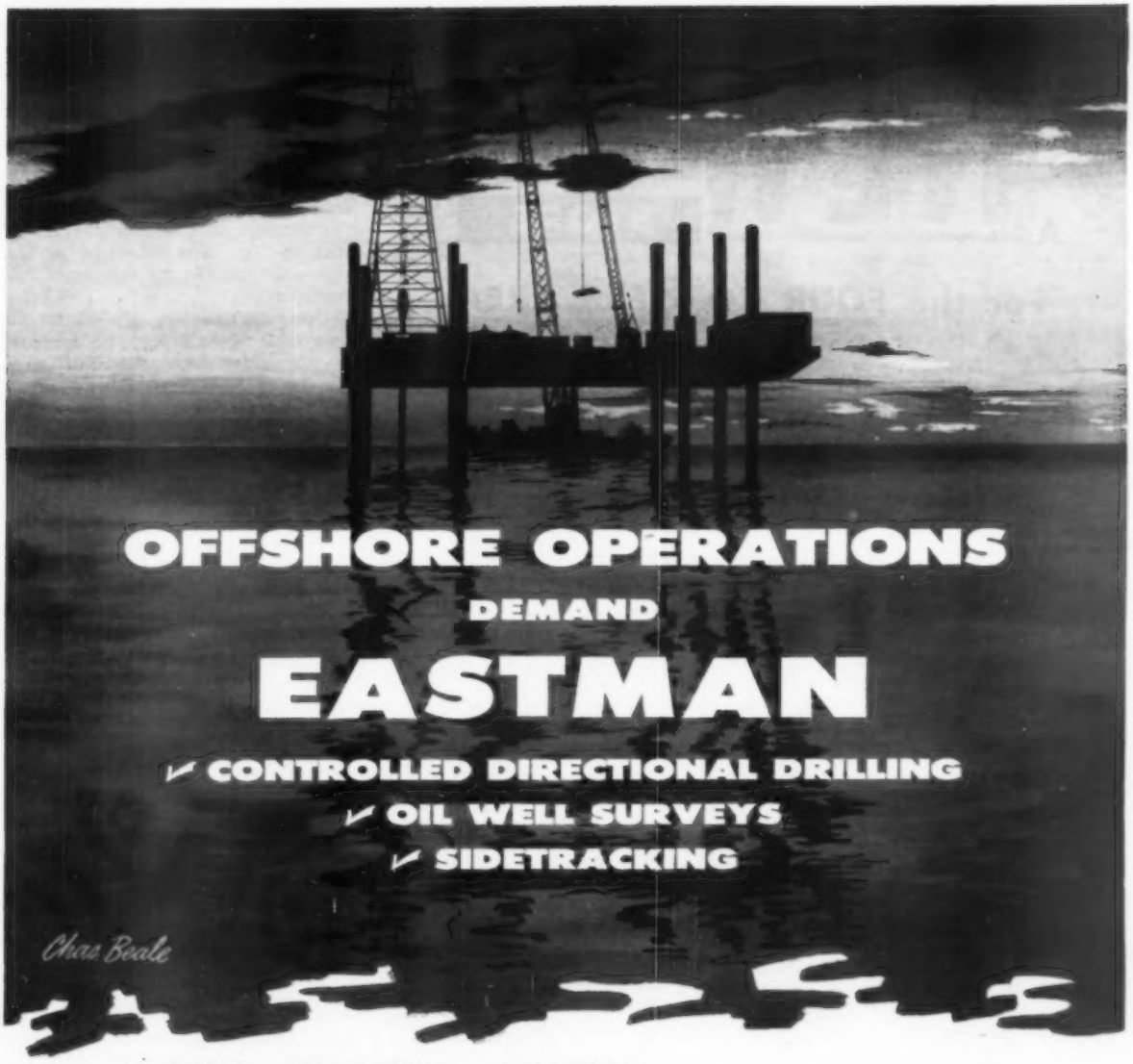

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Triaxial tests on anhydrite under formation pressure conditions gave short term ultimate shear strength in the range 12,000 to 14,200 psi. Compressive strength was approximately 28,000 psi. Bureau of Engineering Research at the University of Texas express the opinion that ultimate shear strength of anhydrite ranges between 40 and 50 percent of ultimate compressive strength. Test data witnessed by the author substantiate the validity of this statement.

Using the foregoing strength data, a reasonable solution can be approximated through assumption of unidirectional stress conditions. With additional basic assumptions, a method for calculating salt cavity limitations can be established. These basic assumptions follow:

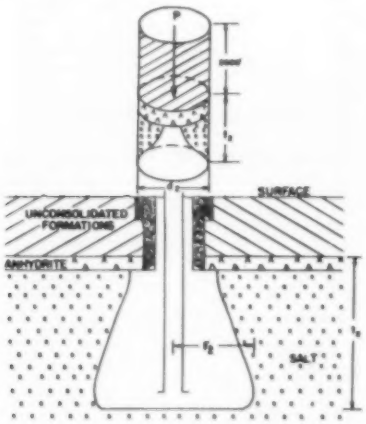
1. The formations overlying a salt cavern act as a punch press inducing a shear stress in the roof of the cavity.
2. The entire overburden is effective in inducing this stress condition.
3. The overburden is assumed to exert 1.0 psi per ft of depth.
4. The effective support for the overburden is the massive anhydrite cap section and the salt section above the maximum diameter of the cavity.

Using the above assumptions, a hypothetical case is carried out here to illustrate storage cavity design considerations. Referring to Fig. 2, effect of method of circulation during cavity development which affects the area under shear loading can be seen. For the purposes here, let us suppose that the anhydrite and salt (at a depth of 2000 ft) are equally strong, having an ultimate compressive strength of 25,000 psi and an ultimate shear strength of 10,000 psi. Assume cavity diameter to be 200 ft.

Effective shear stress has been evaluated for Fig. 2 and 3. With diameters equal for the two cases, storage capacity of the cavity depicted in Fig. 3 is several times (estimated 8 to 10 times) the capacity of the cavity in Fig. 2. It has been indicated that minimum stress conditions exist for a given cavity volume when conventional circulation is used to create a cavern.

It is our purpose now to summarize some suggested cavity size limitations. First, assume that triaxial tests are realistic; because the tests provide short term strength only and because of possible geological unknowns in the beds underground, a factor of safety of 4 will be used, providing long term ultimate shear strength of 3000 psi for the cavity cap (anhydrite).

Salt strength is assumed virtually comparable to anhydrite (data presented earlier indicate salt is much



$$\text{SHEAR STRESS, } Ss = \frac{\text{LOAD}}{\text{AREA IN SHEAR}}$$

$$Ss = \frac{P}{\text{CIRCUMFERENCE} \times \text{THICKNESS}}$$

$$Ss = \frac{\text{lpsi/ft} \times 2000' \times \pi r_1^2}{\pi \times 200 \times 100}$$

$$Ss = 1000 \text{ psi}$$

$t_2 = 100'$
$d_2 = 200'$

FIG. 3. Shear stress in roof of pear shaped cavity. Calculations indicate that this cavity shape permits several times the cavity diameter shown in Fig. 2.

lower in strength) for simplification of our problem. Design considerations for a "jug" filled with salt water, filled with LPG, and empty are shown below based on an assumed depth of 2000 ft.

1. Jug empty

S_s = Rock gradient pressure x depth x area at maximum

$$\frac{\text{cavity diameter}}{\text{Area in shear}}$$

$$3000 \text{ psi} = \frac{\text{Depth} \times \pi d^2}{4 \pi dt}$$

$$= \frac{\text{Depth} \times d;}{4t}$$

$$3000 \times 4t = 2000 d$$

$$6t = d$$

or maximum diameter = 6 x thickness

2. Jug filled with LPG (LPG gradient of 0.22)

$$S_s = \frac{(1 \times 2000 - 0.22 \times 2000)\ \pi d^2}{4 \pi dt}$$

$$6000t = 780d$$

$$7.7 = d$$

or maximum diameter = 7.7 x thickness

3. Jug filled with salt water (water gradient of 0.52)

$$S_s = \frac{(1 \times 2000 - 0.52 \times 2000)\ \pi r^2}{4 \pi dt}$$

$$6000t = 480d$$

$$12.5 = d$$

or maximum diameter = 12.5 x thickness

References

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3. Bridgman, P. W., "Some Implications for Geophysics of High-Pressure Phenomena," Geology Society of America, Bull., Vol. 62, p. 533-536 (1951).
4. Ros, H. C. and Eichinger, A., "Experimental Attempt to Solve the Problem of Failures in Materials" — Non-Metallic Materials, U. S. Bureau of Reclamation, Technical Man. No. 635 (1928).
5. *Transactions*, ASME, Vol. 75, p. 323 (1953).

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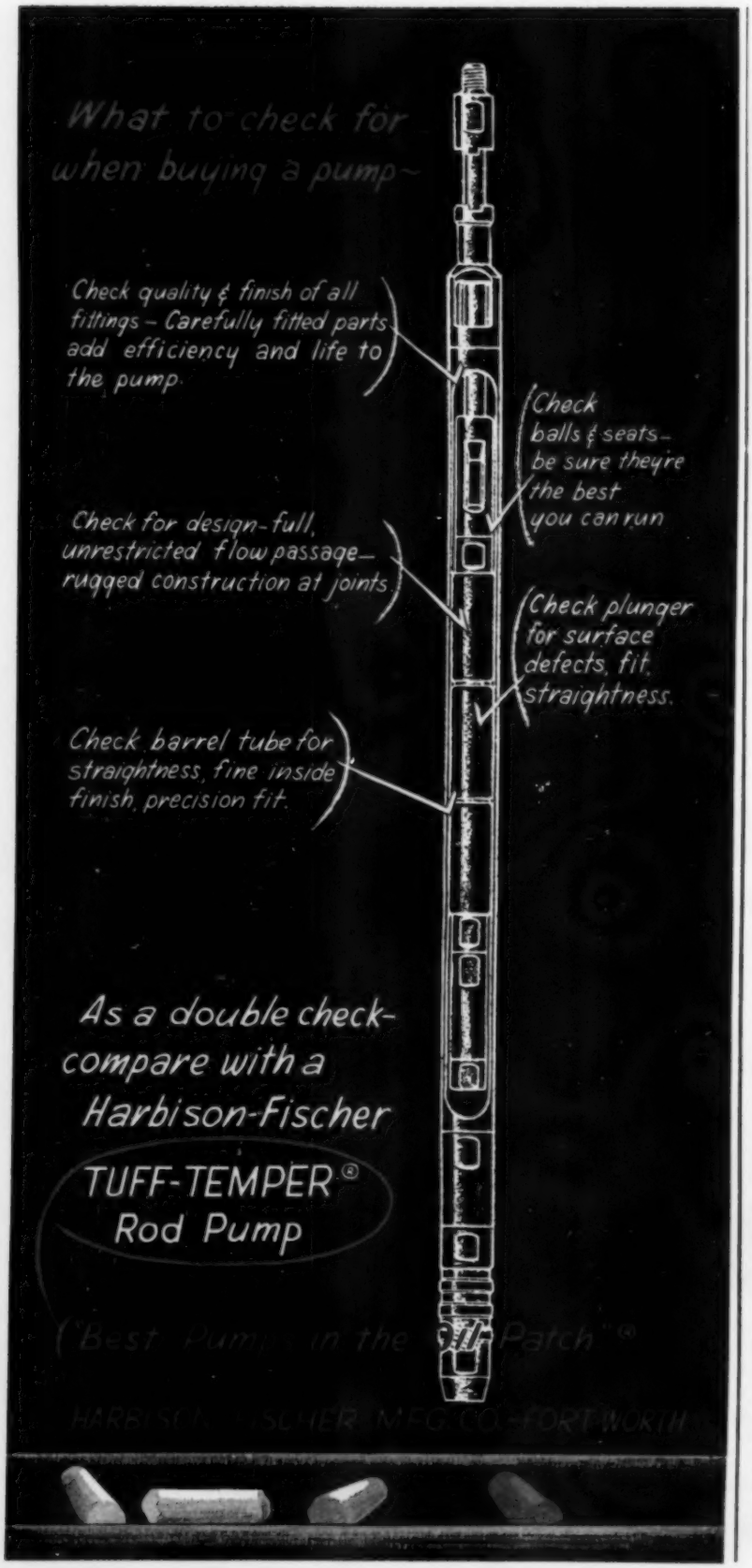
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Check balls & seats – be sure they're the best you can run
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Check plunger for surface defects, fit, straightness.
Check barrel tube for straightness, fine inside finish, precision fit.
As a double check – compare with a Harbison-Fischer
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Rod Pump

AAPG Nominates 1958 Officer Slate

American Association of Petroleum Geologists President Graham B. Moody has announced the new slate of officers nominations submitted by the AAPG nominating committee.

For president, George S. Buchanan, Husky Oil Company, Cody, Wyoming, and Sheridan A. Thompson, Magnolia Petroleum Company, Dallas, Texas, were selected; For vice president Gordon I. Atwater, consultant, New Orleans, Louisiana, and Claude N. Valerius, consultant, Shreveport, Louisiana, were picked. For secretary-treasurer are Kenneth Cottingham, The Ohio Fuel Gas Company, Columbus, Ohio, and Harold T. Morley, Pan American Petroleum Corporation, Tulsa, Oklahoma; for editor, Sherman A. Wengerd, incumbent, University of New Mexico, Albuquerque.

Winners in the election of national AAPG officers, which is by mailed ballot, will take office on March 13, 1958, at the close of the forty-third annual meeting of the association, to be held in Los Angeles, California.

Chairman of the 1958 AAPG nominating committee is William B. Heroy, Beers and Heroy, Dallas, Texas. Other members include G. Clark Gester, Berkley, California, Paul A. Harper, The R. W. Rine Drilling Company, Wichita, Kansas, Robert McMillan, Geophoto Services, Denver, Colorado, and George D. Thomas, Shell Oil Company, New Orleans, Louisiana.

Present members of the AAPG executive committee include President Graham B. Moody, consultant, Berkeley, California, Vice President B. Warren Beebe, Keating Drilling Company, Oklahoma City, Oklahoma, Secretary-Treasurer William J. Hilseweck, Blackwood and Nichols Company, Dallas, Texas, and AAPG Bulletin editor, Sherman A. Wengerd, University of New Mexico, Albuquerque.

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A common scene (above) in the Gulf these days. Dual drilling rigs on platform served by one tender in the West Delta Block 30 field, with production platform in background. **Types of structures** (below) vary widely in offshore operations. Note submersible, self-elevating drilling barge operating in the West Delta area, with platform-tender combination in background.

P 910.

THE GRAPHIC STORY OF

Offshore Oil

It's stop and go as the states and Federal Government hassle over ownership. On the bright side: Discovery rates are high; geophysical costs are low, and rat holes are free!

Donald M. Taylor
Gulf Coast Editor

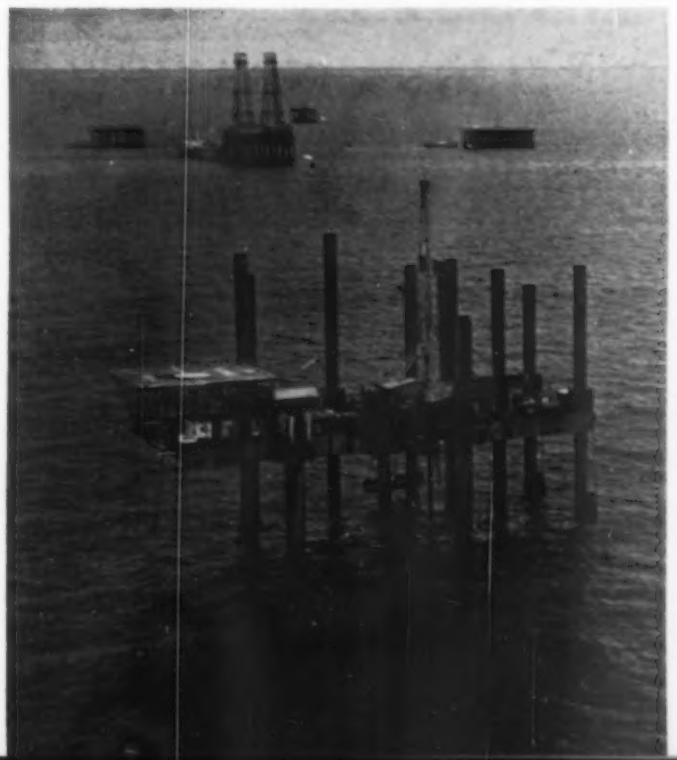
THE chips are royal blue in the Gulf of Mexico oil game, but when the pot's right, your chances of discovering oil or gas in pay-off quantities are considerably better than on land. **Since 1953, almost ⅓ of the wildcats in the water have been discoveries.** It's a bright picture marred only by the low allowables and aimless, diddling finger of the U. S. Government.

About 50 companies (or groups of companies) are playing this offshore trend, and to date, they have shoved well over a billion dollars into the game. So far, the only inexpensive items they have uncovered are rat holes which are free and geophysical exploration which runs only ¼ to ⅓ the cost of equivalent work on land. (Shooting crews can traverse 50 miles on an average fair weather day, and exploration costs seldom exceed 90 cents per acre.)

But most important of all, structures are easy to find. In the Miocene trend that starts at Texas' Red Fish Bay and runs eastward around the entire coast, salt dome structures have proved highly productive, and these are relatively easy to locate and delineate by the seismograph.

Payout

If prospects are easy to find, and the success ratio is high, why worry about the cost of the chips? Just stay in the game and you're bound to win! Actually, it's not this simple. For one thing, there is the matter of pay out. In the



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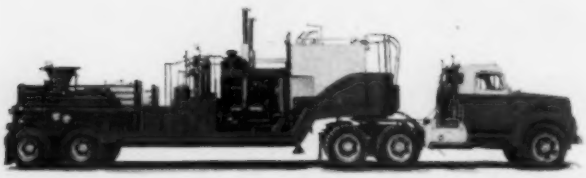
Halliburton has the Casing Equipment to do the job with maximum ease and safety for both casing and formation in almost every "running-in" problem when you're setting pipe, whether it be slim hole, crooked hole, or deep hot hole...

Excellent results have been obtained through the selection of Halliburton float shoes and float collars, guide shoes and related floating equipment in spite of an almost endless variety of—

- unusual or different formation conditions and pressures
- new or different drilling muds or cements
- casing strings of many sizes and types

Special Halliburton-designed Casing Equipment will also help you combat contamination and channeling... enemies of durable cementing protection. Check with your Halliburton representative for more dependable Casing Equipment and service.



HALLIBURTON

OIL WELL CEMENTING COMPANY

DUNCAN, OKLAHOMA

AUTOMATIC FILL-UP FLOAT COLLAR AND FLOAT SHOE... allow casing to be filled automatically while it is being run to bottom. Key feature is a unique orifice-type attachment that "meters" the upward flow of drilling fluids through the Float Collar or Float Shoe. Easily drilled and simply operated, Automatic Floating Equipment not only saves considerable running-in time, but also helps reduce damaging pressure surges on the formation.

TURBO-JET FLOAT SHOE... engineered to not only float and guide casing strings to bottom—but also to help agitate and distribute cement to minimize channeling. Built-in rotor forces powerful jet-stream of fluid through side ports and bottom to agitate cement for more uniform cementing around casing. All parts are drillable.

ADMIX FLOAT SHOE... used where lost circulation additives such as Flocele and Howcogel are mixed with dry bulk cement. If Float Shoe becomes plugged for any reason, specially engineered Safety Plugs pump out at a pre-determined pressure, minimizing the possibility of leaving the casing filled with additive-mixed cement.

TYPE "J" TEXAS PATTERN CASING SHOE... with open end, used in rotary drilled wells of shallow areas and shallow cable drilled wells where it is not necessary to guide or float the casing to bottom. Reinforces end of casing column to reduce damage to casing, aids in running-in past hole obstructions.

TYPE "K" COUPLING SHOE... used when removable securaloy windows are required in production strings of casing. Joins securaloy window sections with permanent steel casing. Cadmium plated.

CEMENTING SERVICES

"PLANNED TO PROVIDE A BETTER JOB EVERY TIME"

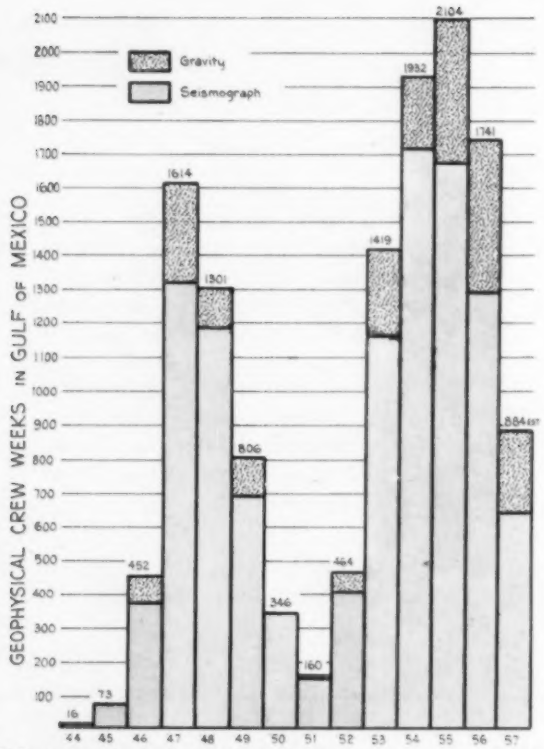


FIG. 1. **Geophysical activity** in the Gulf of Mexico since 1944 is reflected in this account of both gravity and seismograph work by crew weeks.

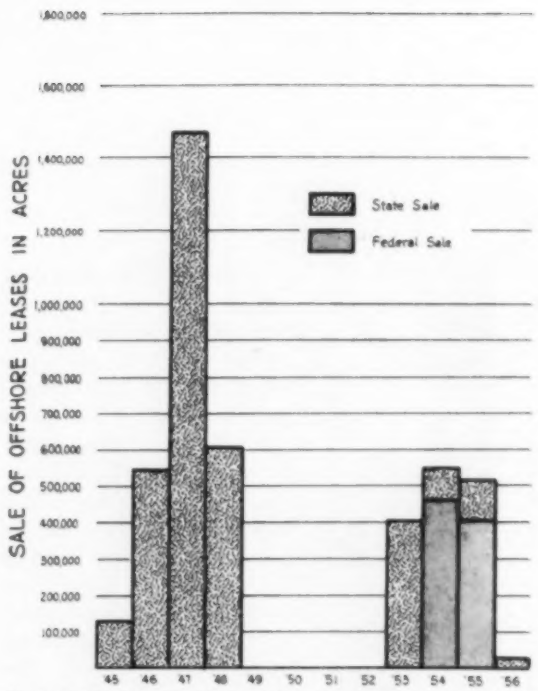


FIG. 2. **Total offshore acres** leased each year shows graphically the effect of the Supreme Court's unforgettable tidelands decision in 1948.

INTERNAL CORROSION SURVEY SERVICE

Otis Tubing Caliper Surveys in the hole under pressure...casing surveys...rod wear inspection

OTIS/Branches Throughout the Oil Country

PRESSURE CONTROL OTIS SERVICE - EQUIPMENT

free world, oil operators seek oil to make money. But because the risk is great, they must spread their venture capital wisely, insuring that discoveries will at least pay for the failures. Too, venture capital should return within a reasonable period to permit the company to stay in the game.

Take a look at the table below, and you'll see why many operators are still on the brink of the salt water plunge:

Unofficial Allowables for the State of Louisiana June 1957.

Depths in Thousands of Feet	Onshore-BOPD Depth Bracket Allowable	Offshore-BOPD Depth Bracket Allowable
0-2	34	82
2-3	41	92
3-4	49	102
4-5	58	115
5-6	68	126
6-7	80	142
7-8	92	163
8-9	103	179
9-10	118	199
10-11	133	219
11-12	149	240
12-13	165	261
13-deeper	185	287
14-15	208	—
15-16	240	—
16-17	283	—

TABLE 1. Wildcat Wells in Gulf.

Year	Total	Dry	Discoveries
1930	1	1	—
1937	2	2	—
1938	6	5	1
1939	4	4	—
1940	2	2	—
1941	3	3	—
1946	4	4	—
1947	3	2	1
1948	15	8	7
1949	28	14	14
1950	11	7	4
1951	4	1	3
1952	9	9	—
1953	16	12	4
1954	46	35	11
1955	70	42	28
1956	74	53	21
1957 (to March)	5	3	2
TOTALS	303	207	96

TABLE 2. Field Development Wells.

Year	Total	Oil	Gas	Dry
1938	3	2	—	1
1939	6	6	—	—
1940	3	1	2	—
1941	4	3	—	1
1942	2	—	—	2
1945	1	—	—	1
1946	3	1	—	2
1947	2	2	—	—
1948	8	4	1	3
1949	50	25	3	22
1950	69	34	9	26
1951	13	8	2	3
1952	53	36	6	11
1953	103	69	11	23
1954	223	153	29	41
1955	369	237	41	91
1956	440	260	55	125
1957	7	1	2	4
Totals	1,359	842	161	356

Where wildcats run $500,000 apiece and up and field development wells $250,000 to $500,000 it's easy to see that the payout on many wells will be long in coming.: Besides, deep-seated domes usually produce gas-condensate, and so far, thanks to governmental dalliance, natural gas has not carried its share of the load.

To date the industry has spent $1.4 billion in the gulf, and revenues have amounted to only $400 million. This leaves the industry $1 billion in the red as matters now stand.

In short, there are no money trees in the gulf—only Christmas trees. And these set atop very expensive platforms that in turn, set atop very expensive leases.

In fact, lease bonuses and rentals account for almost one-half the money spent in the offshore oil industry. But before going into this phase of the operation, let's visit an oil scout to find out just what comprises the offshore oil region.

competition *makes it better!*

THERE'S NOTHING fishy about the benefits of competition. It makes everybody happy because it gives everybody a chance to pick the best. Competition makes oil well cementing better, too. Next time you need a cementing job, pick the company that put competition in the business.

Engineered answers to oil well cementing

BJ SERVICE, INC.

For Detail See Page B-127

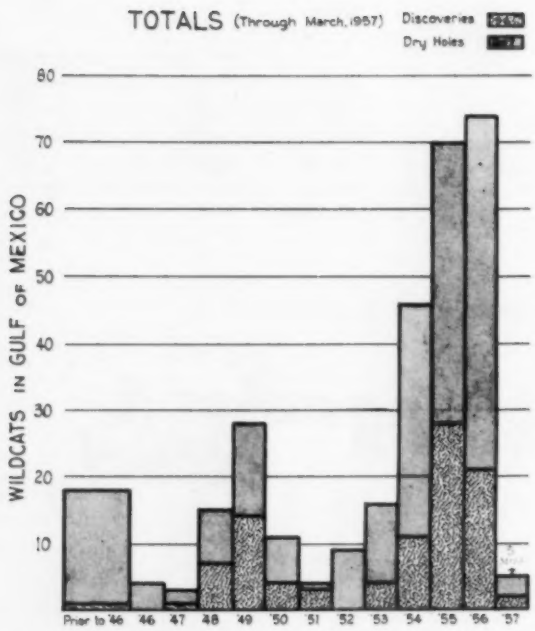


FIG. 3. **Industry's offshore exploratory effort** is indicated by the number of wildcat wells drilled each year. Biggest effort has been since 1953 following passage of Outer Continental Shelf Act.

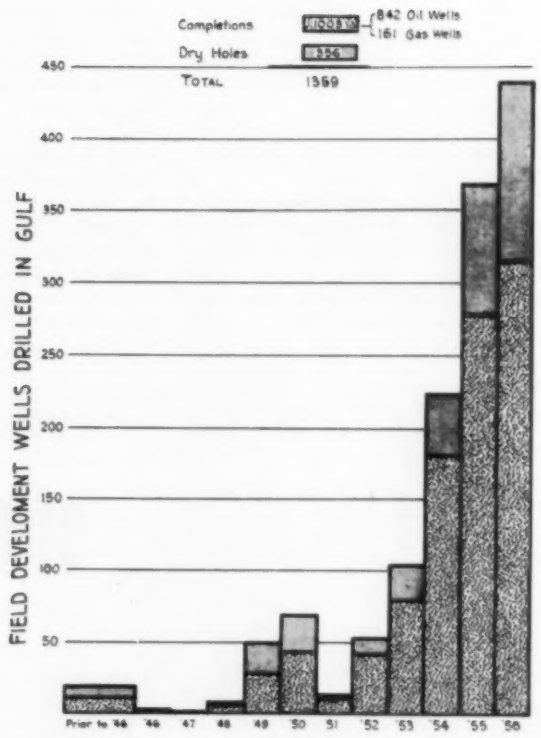


FIG. 4. **Drilling of field development** wells accelerated rapidly following 1953, and dropped considerably in the beginning of 1957.

Where Is Offshore?

To get the information in this article, I called on one of the country's leading oil scouts. His business is that of keeping his own company informed at all times on the activities of rival companies operating in the offshore region. He accomplishes this by exchanging unclassified information with rival scouts in a fantastic game of stud poker — played with odd bits of information rather than cards — and by surveillance.

This particular scout flies over the gulf about two days a week, tracking and identifying geophysical and crew boats, counting stands of pipe on wildcat wells and using every other possible means of keeping up with what is going on in the offshore area.

He has methodically compiled a running history of the Gulf of Mexico's oil activity, which began in earnest about 12 years ago. Week by week he plotted the number of geophysical crews at work in the area and kept track of wildcats and development wells at the same time. Most of the information in the accompanying charts came from his copious records.

What makes up the offshore area as far as the oilman is concerned? He defines it simply as any portion of the gulf or tidelands that is divided into numbered segments by state or federal governments.

When asked about the astounding costs of leases that have averaged about $380 per acre since 1953 (and one went for $2200 per acre!). This particular scout said, "Bidding for offshore leases is so competitive that when a company is awarded a bid for less than double that of the next lowest bidder, if considers itself lucky."

TABLE 3. Crew Weeks of Offshore Geophysical Activity.

Year	Seismic	Gravity	Total
1944	16	—	16
1945	73	—	73
1946	336	116	452
1947	1,320	294	1,614
1948	1,185	116	1,301
1949	691	115	806
1950	342	4	346
1951	147	13	160
1952	404	60	464
1953	1,166	253	1,419
1954	1,759	173	1,932
1955	1,677	427	2,104
1956	1,293	448	1,741
1957 (est.)	624	260	884
Totals	11,033	2,279	13,312

TABLE 4. History of Leases in the Gulf of Mexico.

	LOUISIANA		TEXAS		TOTAL	
Date	Acres	Bonus	Acres	Bonus	Acres	Bonus
1922 (state)	—	—	775	577.60	775	577.60
1945 (state)	129,000	661,000.00	—	—	129,000	661,000.00
1946 (state)	545,000	4,800,000.00	—	—	545,000	4,800,000.00
1947 (state)	1,095,000	9,500,000.00	375,000	7,200,000.00	1,470,000	16,700,000.00
1948 (state)	606,000	10,500,000.00	—	—	606,000	10,500,000.00
1949 (state)	—	—	—	—	—	—
1950 (state)	—	—	—	—	—	—
1951 (state)	—	—	—	—	—	—
1952 (state)	—	—	—	—	—	—
1953 (state)	—	—	403,000	32,000,000.00	403,000	32,000,000.00
1954 (state)	90,000	37,000,000.00	360	19,000.00	90,360	37,019,000.00
1954 (federal)	395,000	115,000,000.00	67,000	23,000,000.00	462,000	138,000,000.00
1955 (state)	57,000	56,000,000.00	59,000	6,800,000.00	116,000	62,800,000.00
1955 (federal)	253,000	100,000,000.00	150,000	8,500,000.00	403,000	108,500,000.00
1956 (state)	24,000	13,500,000.00	4,600	289,000.00	28,600	13,789,000.00
1957 (state)	—	—	—	—	—	—

Correct Counterbalance is Essential to the Life and Performance of your Unit!

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Correct Counterbalance Means:

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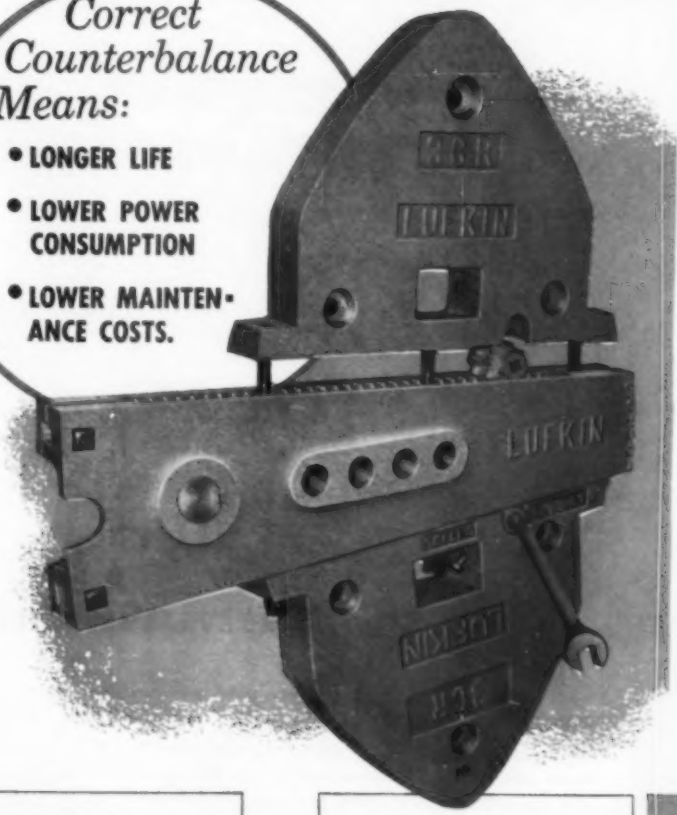
- **LOWER POWER CONSUMPTION**
- **LOWER MAINTENANCE COSTS.**



Makes Counterbalance Adjustment Simple and Easy

1. Move cranks to horizontal position and set brake.
2. Loosen nuts holding counterweight using wrench as furnished and sledge hammer.
3. Loosen set screw with ordinary crescent wrench.
4. Insert square on wrench handle into socket in end of pinion and rotate, moving counterweight to desired position.
5. Tighten nuts on counterweight bolts, using wrench and sledge.
6. Tighten set screw.

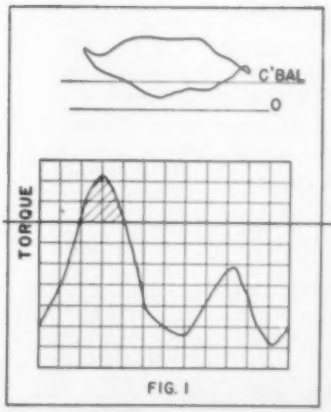


FIG. 1

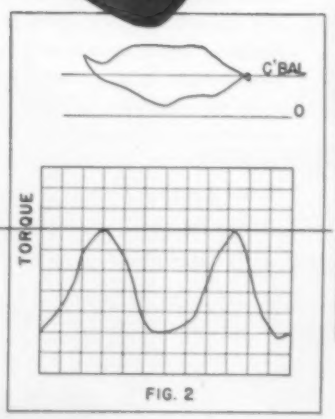


FIG. 2

FIGURE 1. Illustrates the results of incorrect counterbalance. Note peak torque on up stroke exceeds rating of gears.

FIGURE 2. Torque curve on same well shows how proper counterbalance evens out the peaks and reduces peak torque to within gear rating.

• Lufkin Gears, when operated within their rated capacity, will give many years of trouble free service.

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IN THE WORLD

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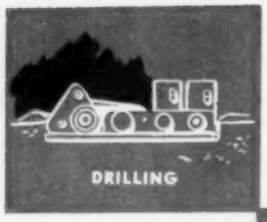
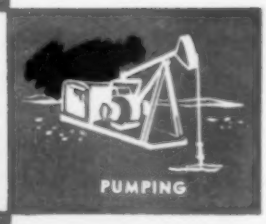
LEADS THE FIELD





Gas Engine Carburetion

Gas engines operating in the remotest parts of the world, frequently in the hands of the most inexperienced, must be easy to start, easy to operate and easy to service. This calls for gas carburetion that is simple in design and rugged in construction. Toward this end ENSIGN engineers have concentrated their efforts and resources for nearly half a century. Results of this concentration of purpose are measured in terms of unparalleled gas engine performance. Proof of this comes in a quick glance at the gas engine market. Today hundreds of thousands of ENSIGN carburetors are in a 'round-the-clock operation throughout the world rendering indisputable evidence that engines equipped with ENSIGN can be depended upon to perform well under all conditions.

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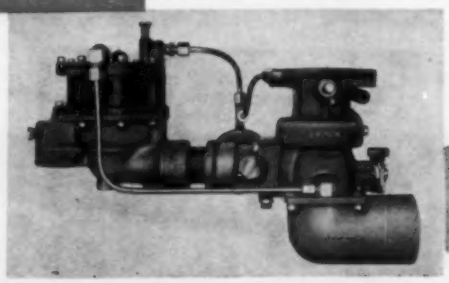

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For contractors who specialize in deep well servicing, Bucyrus-Erie offers a combination that's hard to beat for time-saving and profitable operations — a specially designed 85-ft. servicing derrick for use with the company's 48-L spudder. Here's a compact traveling unit that provides ample height, big capacity (handles 60,000 pounds of tubing), and strong structural design for fast, profitable clean-out, rod and tubing, or other servicing work.

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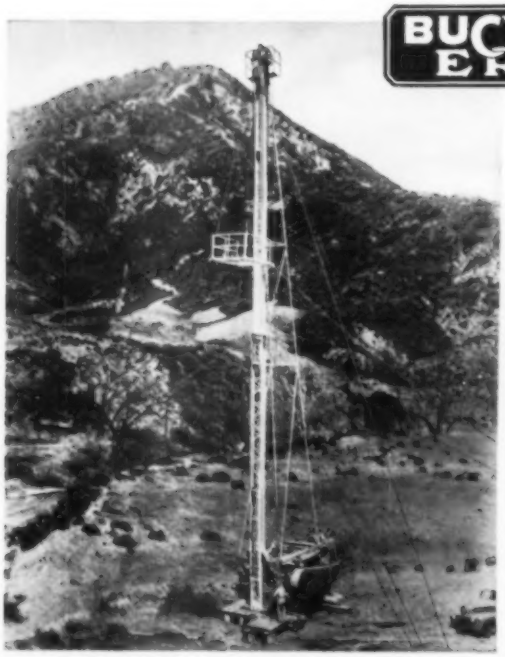

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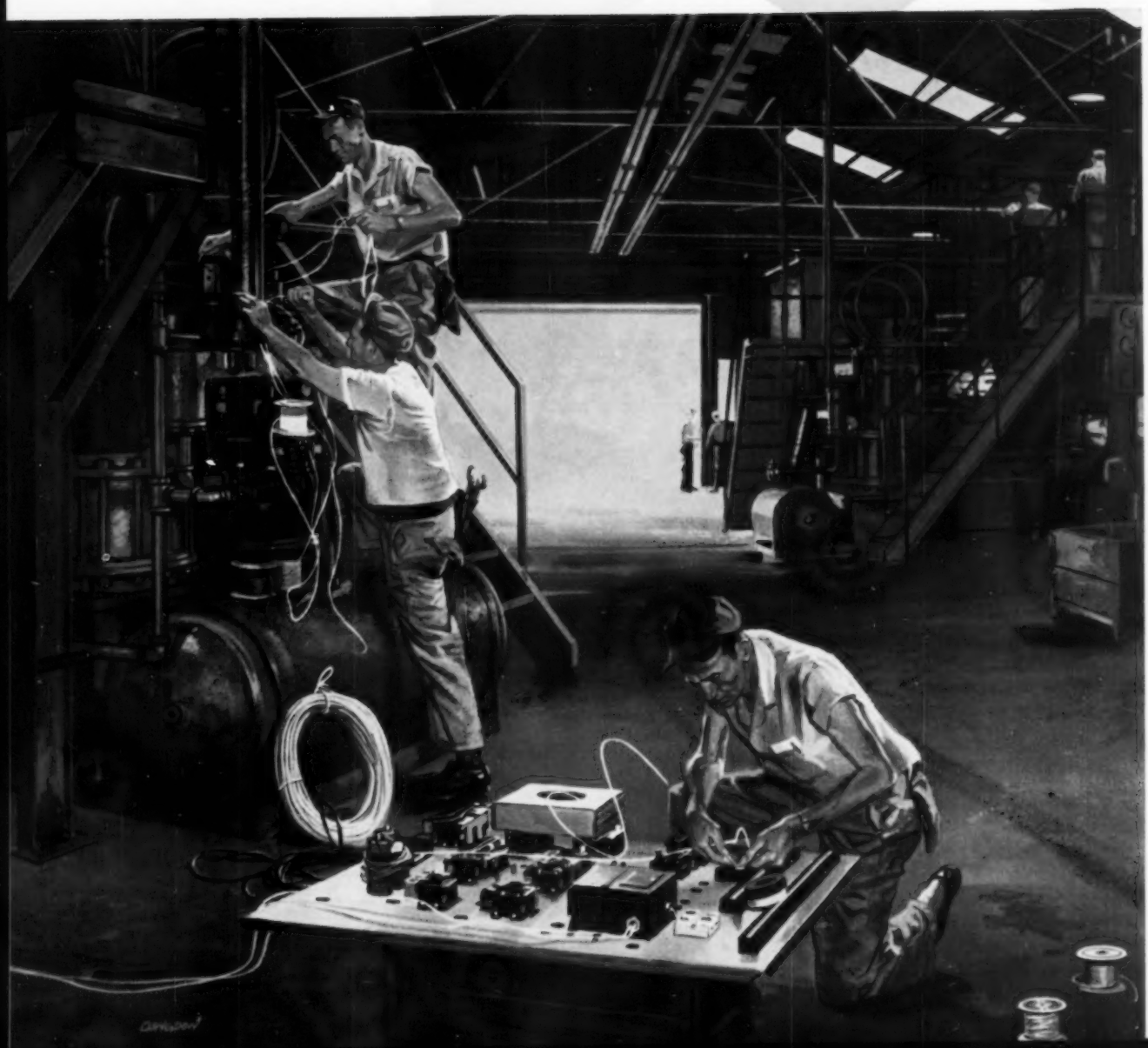

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Flash Welded to Drill Pipe

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Reed is the only manufacturer of flash welded tool joints that can make the foregoing statement. This unexcelled record of Reed *Flash Welded* Tool Joints is a direct result of Reed's more than twenty-five years of leadership experience in the manufacture of all types of tool joints. Reed has successfully produced approximately *two million pairs* of tool joints.

Installation of this second giant resistance welder, custom-engineered to Reed's specifications, will double Reed's capacity to produce flash welded tool joints and make delivery to your requirements. Every precaution will be taken to insure that this second machine will maintain Reed's record of never having had a failure in a weld.

Whatever your requirements in standard or special tool joints, ask the leader — ask your Reed man!

REED ROLLER BIT COMPANY

HOUSTON 1, TEXAS

By B. R. Dixon,
Johnston Testers

FOR MORE INFORMATION AT THE BOTTOM OF YOUR WELL

Important points on double shut-in pressures

"What is the main advantage of double shut-in pressure readings?" That's a question often asked by those who have not yet tried this newest method of drill stem testing.

Actually there are four main advantages of the double shut-in pressure method:

1. Maximum formation pressure build-up in shortest time.
2. Comparison of reservoir build-up pressures before and after test.
3. Two separate chances to obtain reservoir pressure.
4. The measuring of the true equilibrium pressure prior to producing the formation provides a virgin pressure measurement and more accurate data.

Perfected by Johnston Testers, this new technique requires only a simple rearrangement of the test tool assembly. By placing a valve above the main or hydraulic valve, a specified volume of air is trapped between these two valves. This volume of air is called the "air chamber."

As the purpose of the air chamber is to relieve the mud pressure trapped below the packer, the secret of success of double shut-in testing is accurate use of this air chamber. Best results have been obtained when volume of the air chamber is about 10% of the volume of mud below the packer.

In the past, it has been common to calculate the air chamber to the nearest 30-foot pipe length. This lack of accuracy has often caused a failure to record the maximum initial shut-in pressure.

To overcome this problem, and to do away with complicated mathematics, Johnston has developed an "air chamber alignment chart." By simply drawing straight lines between known figures, the amount of air chamber needed can be calculated quickly and accurately.

Complete information on double shut-in testing is available from Johnston Testers, Houston, Texas. Write today for complete descriptive folder.

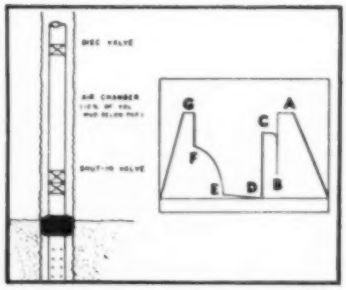

Figure 3
Testing tool assembly for double shut-in pressure readings which permits a limited fluid withdrawal. By placing the disc valve above the main or hydraulic valve so that a specified volume of air is trapped between these two valves.

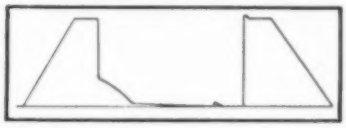

Figure 4
Well not capable of producing fluid fast enough to fill up air chamber and cause pressure build-up.

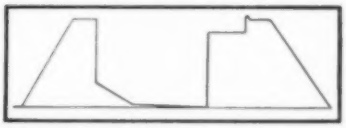

Figure 5
Mud did not expand enough to get pressure draw-down below the formation pressure.

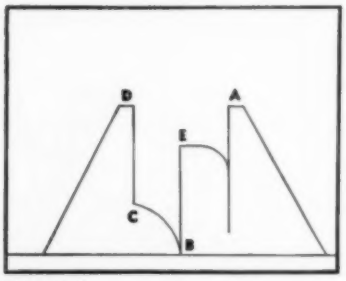

Figure 1
Example of a chart on an interval that has good permeability. The initial shut-in shows the formation pressure before the reservoir has been disturbed. The rapid build-up of the flow curve from "B" to "C" indicates rapid entry of fluid into the drill pipe. In this case the formation gave way allowing the hydrostatic pressure to stop the test. If the initial shut-in had not been taken another test would have been necessary in order to determine the reservoir shut-in pressure.

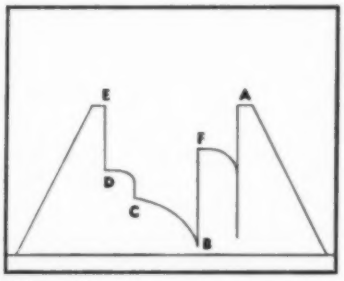

Figure 2
Example of a test in a very small reservoir. The initial shut-in pressure indicates a good initial pressure and the flowing curve shows good recovery, yet the final shut-in curve has almost leveled off to a point much lower than the initial reservoir pressure. This indicates that the reservoir is very small and even the short producing time of the drill stem test has partially depleted it. A follow-up test of the same interval is advisable.

B. R. Dixon, M.E.
Sales Engineer
Johnston Testers
Dallas, Texas

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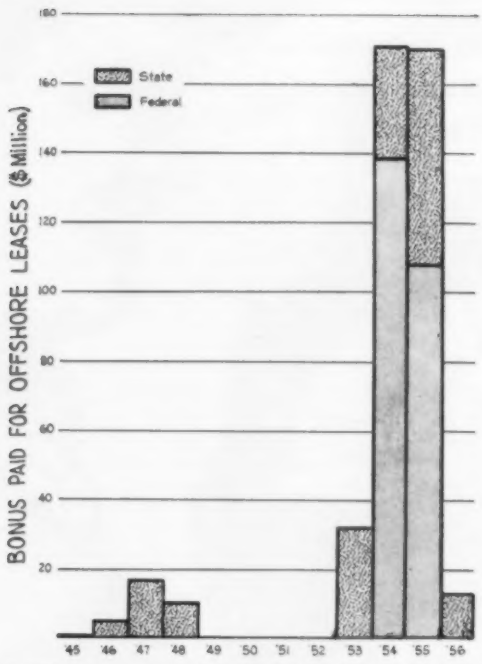


FIG. 5. **Total lease bonus** take by State and Federal government by years since 1945. No offshore sales were made in the first three months of 1957.

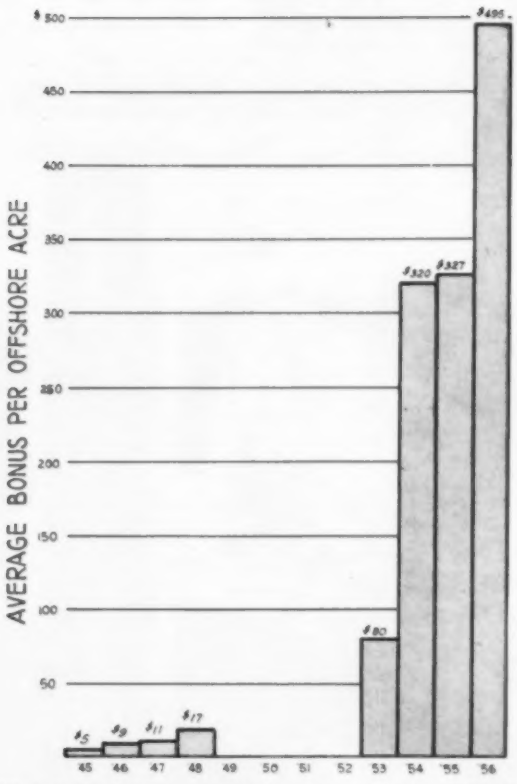


FIG. 6. **Average bonus per offshore acre** reached an all-time high last year of nearly $500 per acre. Some Louisiana tracts brought up to $2200 per acre that year.

How Much for Leases?

All told, oil companies have paid state and federal governments well over half a billion dollars for leases that lumped together would make a square only 80 miles long and 80 miles wide. Contrast this with a bonus of 75 cents per acre paid the state of Texas back in 1922 for a 775-acre lease in the gulf.

The real start of offshore oil operations came on August 14, 1945 when the state of Louisiana held a lease sale at which one operator purchased 129,000 acres for $616,000.00. But before this time there had been sporadic attempts to venture into the offshore. In 1925-26, Mr. Barton McCollum of McCollum Exploration Company, did experimental work, flying an airplane off Galveston Island and attempting refraction shots overhead with recording instruments in the water. The procedure was unsuccessful. A year later, the first underwater seismic cable proved successful, and known domes five miles off Vermilion, Cameron and St. Mary Parishes were found by seismograph.

Superior Oil Company tried the new method and on March 11, 1938, brought in the discovery well at Creole field. It was 9394 ft deep and produced 318 bbl per day from 5110-30 ft interval. Shortly after, Humble Oil & Refining Company stepped out into the water and drilled five wildcats off McFadden Beach, off Jefferson County, Texas.

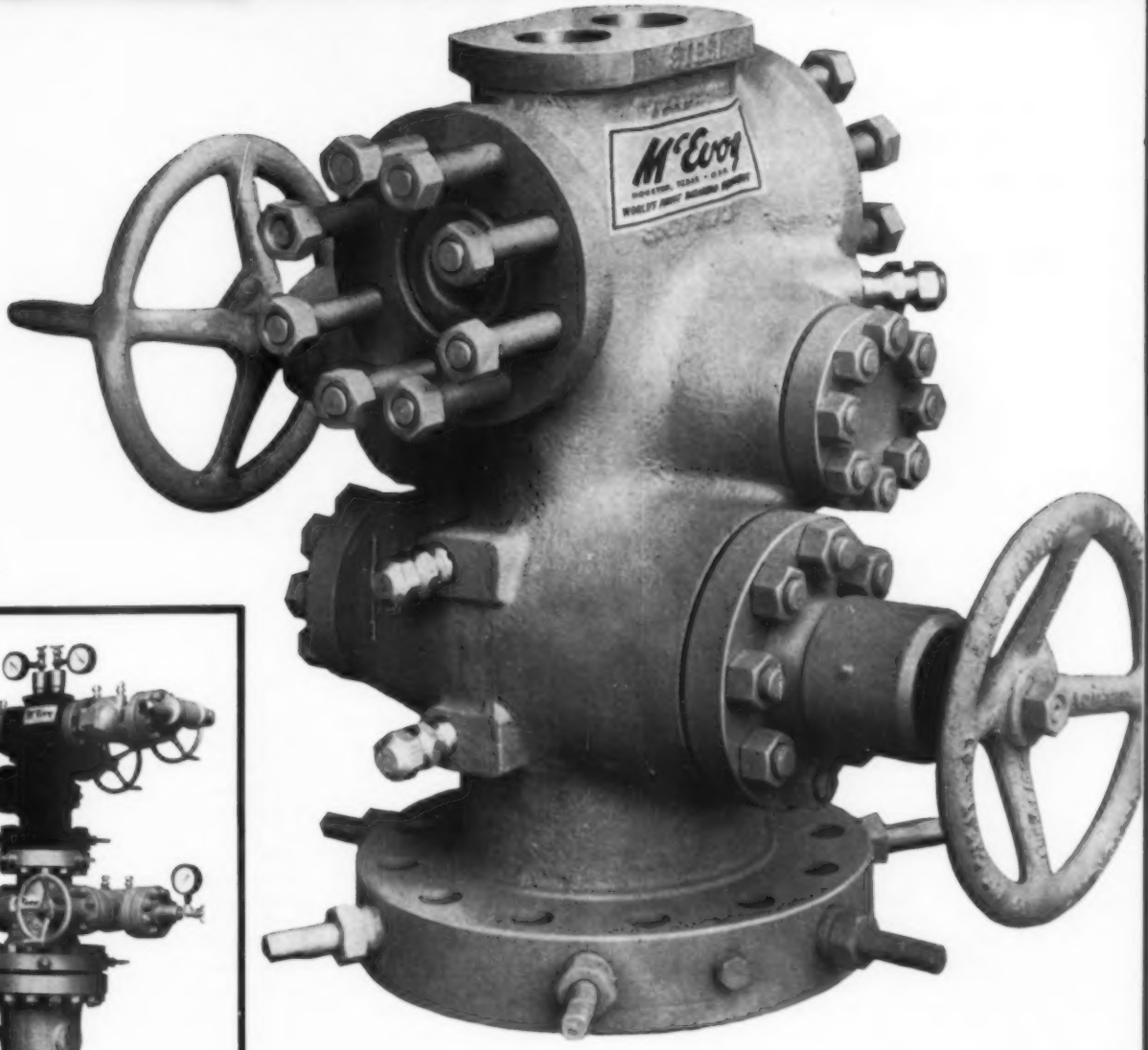
Perhaps Magnolia Petroleum Company's wildcat in Block 58 in the Eugene Island Area was the first real attempt to find oil in the offshore areas as we know them today. This well was spudded in August 1946 and drilled to a total depth of 12,874 ft. Despite its technical success, the well was dry and abandoned. The first producer on lands leased since 1945 was Kerr-McGee's Well No. 1-A in Block 32. This was a 600-bbl well.

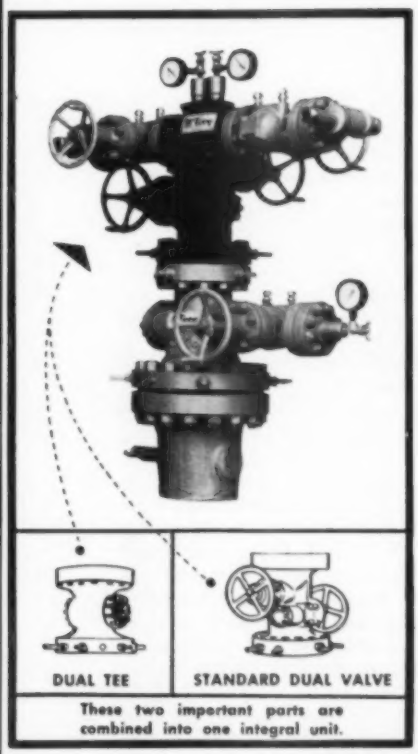
All of the accompanying charts reflect the ups and downs of governmental controversy over offshore properties. Between 1947 and 1950, the U. S. Supreme Court overturned the principle of state ownership of tidelands, ruling against California, Texas and Louisiana, declaring the United States had paramount rights which transcended mere rights of ownership in the state. As a result leasing was suspended in March 1950 along with all but token geophysical activity and drilling. The stalemate ended in August 1953 when President Eisenhower signed the "Outer Continental Shelf Act," and operations once more moved seaward.

Still two major issues are unsettled, and the shifting winds of legal controversy whip up foreboding seas in the offshore oil industry. **Ownership of vast portions of offshore lands are hanging on court decisions, and a sensible natural gas act has yet to be passed.**

What of the future? Activity in the offshore regions is zipping along at a fairly high rate today; and optimism over the natural gas bill is on the high end of the seesaw for a change. Should a favorable bill pass, look for widespread pipelining in the gulf, especially off the western end of the Louisiana Coast. This will be followed by increased drilling, because a pipeline can change the economics of minor discoveries and add incentive to exploration.

If other legal matters are cleared up and allowables raised enough to combat the high cost of money, the offshore oil activity will swell into a massive boom — after all, geologists have variously estimated the reserves all the way from 5 to 8 billion bbl. And, we know the industry will spend well over one dollar per barrel in discovering reserves. This could shape up into the biggest boom yet! ★ ★ ★





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P 537.

In Lake Maracaibo, Venezuela, Creole Petroleum Corporation inaugurates . . .

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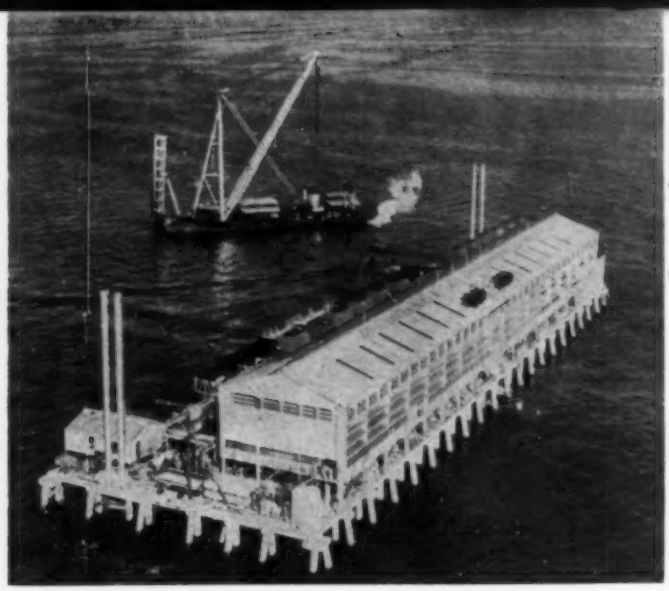

96,000 hp to compress 300 million cu ft of gas daily in $28 million plant on 440 by 131-ft concrete platform located seven miles from shore in 85 ft of water

THE world's largest compressor station, Conservation Plant Tia Juana 2 costing $28 million and located in 85 ft of water seven miles from shore in Lake Maracaibo, Venezuela, was inaugurated recently by Creole Petroleum Corporation. It is the seventh project to be put into operation by Creole whose long-range gas conservation program will require an ultimate investment by 1960 of about $175 million. A third plant in the Lake is now in the planning stage.

Only 2½ years ago, Creole's Conservation Plant Tia Juana 1, designed for 137 million cu ft of gas daily, was put in operation as the world's largest compressor station at that time. (See "Conservation Comes to Venezuela," PE, February 1955, page E-11.) Design capacity of Plant 2 is more than twice that of Plant 1, and will inject about 300 million cu ft per day into four zones of the LL-453 reservoir underlying the lake. Not only will gas be conserved for future use, but the pressure maintenance program is estimated to increase oil recovery by at least 33⅓ percent. The new plant is about six miles south of Plant 1, and in many ways, is a duplication of the first plant. But, it has also been modified to a certain extent from the first plant on the basis of experience gained in construction and operation.

At dedication ceremonies at Tia Juana 2, H. W. Haight, president of Creole, stated that "the inauguration of the plant constitutes the most important step that Creole has taken in its long-range program relating to the efficient production of oil and the conservation of gas." He added that the company plans to start construction of a third plant in the Tia Juana area in July of this year and that still another plant is under study for the Bachaquero area.

Plant's purpose: Basic objectives of these plants are (1) to increase the ultimate recovery of oil from prolific sandstone reservoirs through maintenance of pressure at high levels; (2) to conserve gas until it can be used effectively at some future time; (3) to permit lower operating costs through continued production of wells by natural flow rather than by artificial lift methods; and (4) to increase the efficient rate of recovery of crude oil.

Power plus. Construction work on Tia Juana 2 was begun in September 1955, and was completed in April 1957. (The plant has been operating under test for the past two months to assure proper functioning.) Some 25,000 cu yards of cement and 15,000 tons of steel were required for its construction. It houses 12 gas turbines of 8000-hp each which drive a like number of centrifugal compressors. **This constitutes the largest single concentration of gas combustion turbines in the world.**

Gas Conservation-Pressure Maintenance

In the past, technical and economic factors prevented extensive utilization or conservation of gas, and much of it was flared or vented to the open air. For many years, the solution of these technical problems has been the object of intense study by Creole engineers. Not all reservoirs respond favorably to the injection of gas, but LL-370 and LL-453 reservoirs respond better to gas injection than to waterflooding or other methods. After delineating the very large reservoirs involved and completing engineering studies, not only with respect to the reservoirs themselves but also to the compression system, the optimum injection rate and the economic factors involved, Creole was able to go ahead with a large part of its program.

Previously there had been only two major outlets for gas: One was its use as fuel by the oil industry itself and the other was as an agent for pressure maintenance in producing reservoirs. A small amount of gas also had been provided for industrial purposes. With the steady growth of the Venezuelan economy, however, this picture is now changing. Substantial industrial and domestic markets for gas are beginning to develop, and a start has been made on the construction of pipelines to carry the gas from producing field to market.

The gas being handled by our conservation plants contains large quantities of liquefied petroleum gases and natural gasoline. The growing demand for energy in both the Venezuelan and export markets led to a study of possible sales of these products. The findings indicated good eventual prospects. Consequently, it was decided to proceed with the construction of the LPG plant at Ulé which will process the liquids extracted from the gas stream of Plant 1. The Ulé plant will produce 5300 bbl of propane, 5600 bbl of butane and 6000 bbl of gasoline daily.

Need for Plant 2. Preliminary studies looking toward the construction of Plant 2 as a major project in Creole's

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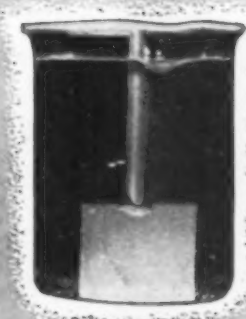

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conservation program began soon after it became apparent that an important new oil-producing area had been opened with the discovery well, LL-453, which was completed in April 1945. Initial production from this well was a little more than 3000 bbl a day from Eocene sands. These sands are a major producing formation of the Bolivar Coastal field. The LL-453 reservoir originally was intended to be an outpost to extend the southern limits of the LL-370 area, but it assumed almost immediately the status of a major discovery well.

Reservoir Characteristics

The four reservoirs of the area are truncated Eocene monoclines bounded by a Miocene-Eocene unconformity, lateral faults and a down-dip oil-water contact. The surface area of the reservoirs is 9874 acres and the thickness of the section ranges up to 410 ft. The net thickness of the producing sands ranges up to 360 feet, with an average of 225 ft. The reservoirs are similar to the LL-370 reservoir in that most of the physical properties show large and systematic variations. The structures dip gently (2 to 6 deg) from the unconformity on the west to the south and southeast.

Estimates indicate that the injection of gas into the reservoirs through Plant 2 will increase the amount of oil that eventually can be recovered by a little more than one-third the amount recoverable without pressure maintenance. Immediate production rates also may increase, but such an increase probably will be negligible and, in fact, rates in some individual wells may decrease slightly.

The most important result will be the maintenance of pressure which will prevent production from declining as much as it has in the past and will enable producing wells to continue to bring oil to the surface through natural flow, plus the fact that the amount of oil eventually recoverable will be greater. Were it not for the injection of gas, pressure would decline gradually and the wells prematurely would have to be produced either through the use of pumps or other artificial lift methods.

The present producing mechanism of the reservoirs is dissolved gas drive with some gravitational segregation and the formation of a secondary gas cap.

Marine Pipeline System

To get gas to the plant where it is compressed and then to move it to the wells where it is to be injected into the reservoirs requires more than 28 miles of pipeline laid on the bed of the lake. Preparation of this pipe to give it the maximum protection against the corrosive effect of the lake water, and to weight it so that it will stay in place, together with the placement of the pipe after it had been thus prepared, was one of the most difficult jobs of the entire project.

The pipeline system comprises two parts: The gathering system which carries the gas from flow stations to the plant, and the injection system which carries the pressurized gas from the plant to the injection wells.

The gathering system connects 12 flow stations to the plant through three different sizes of pipe: 16, 24 and 30 in. in diameter. A total of 121,500 ft of this pipe was used.

The injection system employs 29,100 ft of 10-in. pipe.

The procedure followed in weighting the gathering system lines, to overcome their natural buoyancy, was similar to that employed with the pipe used for the gathering system of Plant 1. An initial coat of asphalt was followed by a wrapping of fiber-glass cloth and heavy mesh wire, to which a heavy coating of concrete (4½-in. in thickness) was applied.

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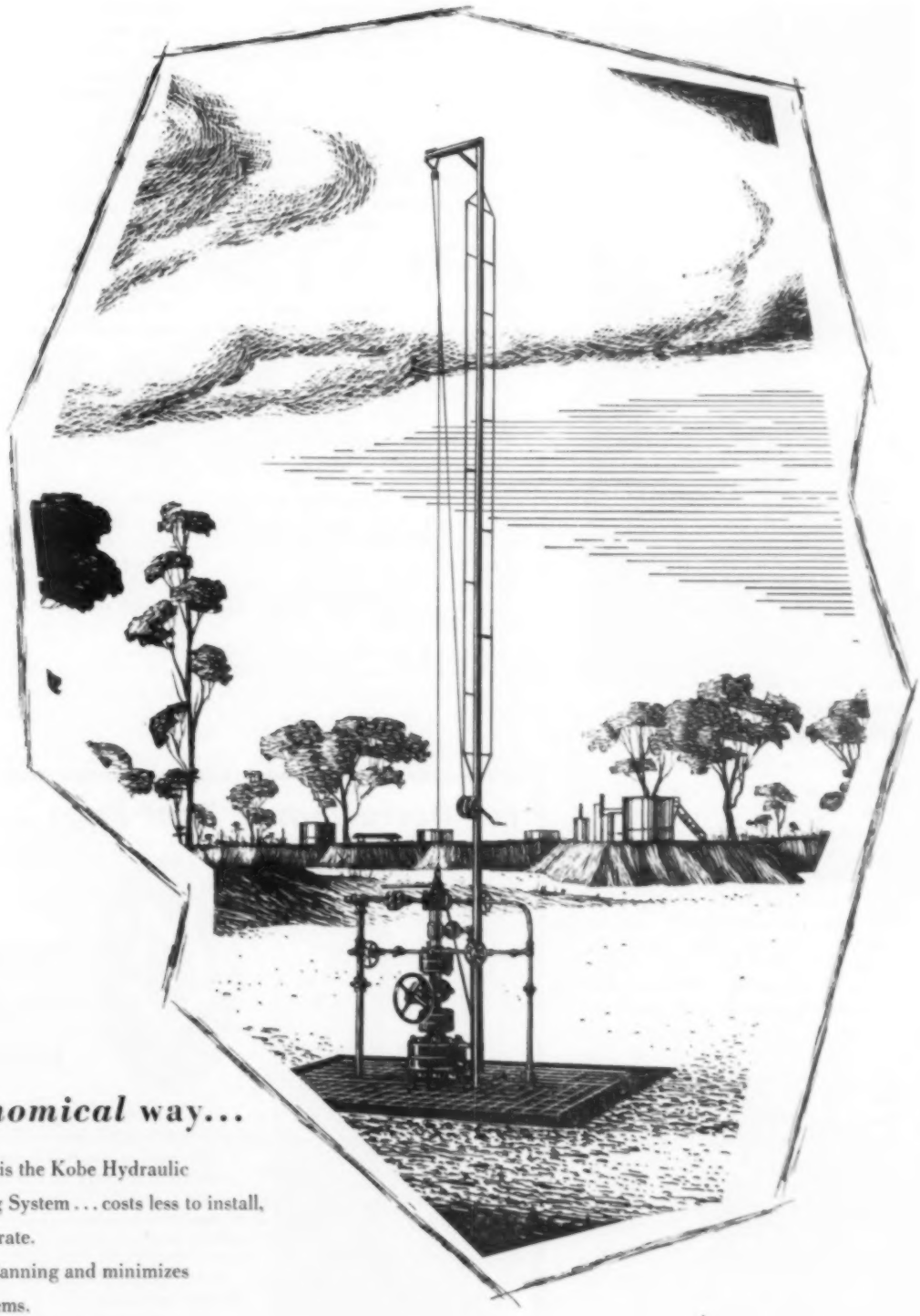

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Plant and Power Facilities

The plant is built on a platform that is 440 ft long and 131 ft wide, longer but narrower than that of Plant 1. The platform rests on 350 piles that are driven into the lake bed. Water depth at the plant site is 85 ft (20 ft deeper than at the site of Plant 1), and the plant platform stands 15 ft above the water. The piles that support the platform are 200 ft long, of reinforced concrete, tapered from 36 by 36-in. at the base in the lake bed to 24 by 24-in. at the top. These piles are among the largest used by Creole in the lake. They are considerably larger than those used in Plant 1, and as a result 45 fewer were used.

All the piles were cast in Creole's two yards at the La Salina industrial base. These piles, as well as the huge concrete slabs that were cast to be used in the platform itself, had to be fabricated under a carefully planned work schedule, so as not to interfere with the regular job of casting piles used in building foundations for wells in the lake. In fact, as was the case in the construction of Plant 1, the most careful coordination was necessary in the step-by-step construction process to hold to a minimum the interference with the use of the pile-casting yards, barges and pile-drivers and other equipment in routine work on the lake. Construction work on the plant was begun in September 1955, nine months after the inauguration of Plant 1, and was completed April 17, 1957. Some 25,000 cu yards of cement were required for the plant. Prior to its inauguration in June, the plant was tested for two months in order to eliminate "bugs," and ensure its smooth functioning.

The framework of the plant building is of steel, and gleaming corrugated aluminum was used to sheathe this framework. The turbines, centrifugal compressors, control room, machine shop, showers, change-rooms and sanitary facilities are located on the upper floor, while scrubbers, coolers and other equipment needed in the complex facilities of the plant are on the lower level. The plant also has four cranes, one with a 40-ton capacity to handle the turbines and compressors; an auxiliary 20-ton crane, and two smaller cranes on the loading platform of the plant to handle materials brought to the site aboard launches and barges. Approximately 15,000 tons of steel were used in the construction of the plant.

The two-story building which houses the plant covers an area slightly larger than that of Plant 1. Its dimensions are

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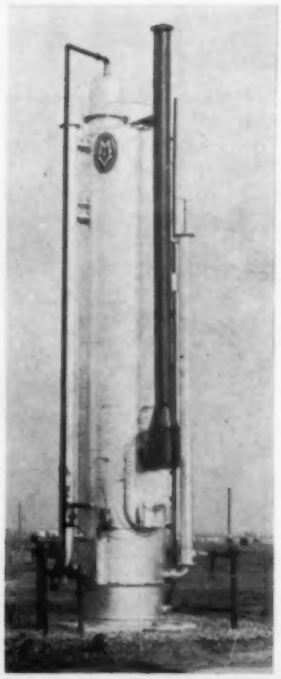

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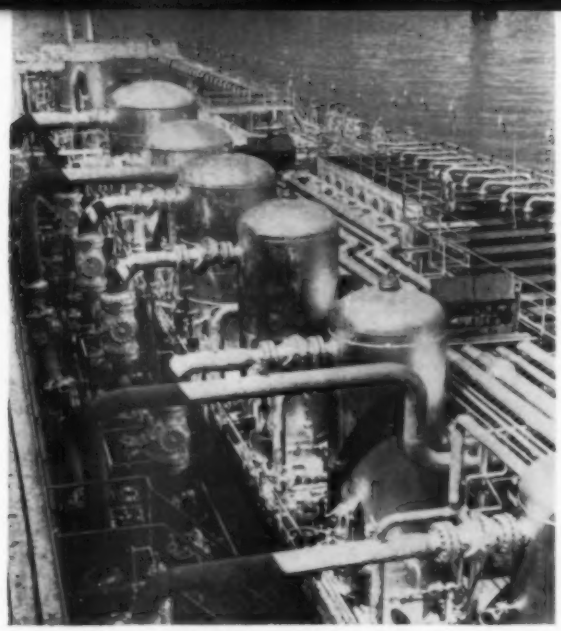
56 by 418 ft (as against 75 by 305 ft at Plant 1), and it covers an area of 23,408 sq ft. The peak of its roof stands 60 ft above the platform. Twelve gas turbines of 8000 hp each drive a like number of centrifugal compressors. This imposing array of turbines constitutes the largest single concentration of gas combustion turbines in the world, a distinction formerly held by Plant 1, which boasts 60,000 hp in its turbine. The driving power of Plant 2 totals 96,000 hp, more than half again as much as that of Plant 1. The turbine and compressor units in Plant 2 are arranged in two six-stage compressor systems operating in parallel.

The experience gained during design, construction and operation of Plant 1 aided considerably in the design and construction of Plant 2. The third Lake Maracaibo plant with the same gas handling capacity as that of the second is in the early stages of design and should be in operation in 1959. It will service the TJ-102 area.

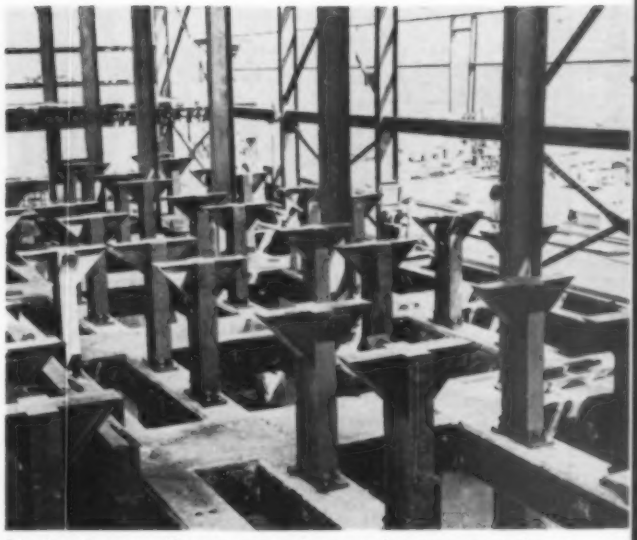
Creole's conservation plans. To serve the system of lake conservation plants and to meet future gas requirements in the BCF area, an integrated overall gas gathering system has been studied and preliminary design work on the initial phase of the system is under way. The system will be designed so that it may be expanded as needed until essentially all the gas produced in the area is gathered. Since the gas in this area is produced at low pressures, pressure drops in the lines have to be kept at a minimum. In order to gather gas

TABLE 1. COMPARATIVE STATISTICS CONSERVATION PLANTS TIA JUANA 1 AND 2

	Plant 1	Plant 2
Platform dimensions	143 by 329 ft	131 by 440 ft
Platform areas (sq ft)	47,047	57,420
Water depth at plant site	62	85
Piles used for foundation	350	305
Size of piles	24 by 24 in.	36 by 36 in. tapered to 24 by 24 in.
Cubic yards of concrete used	19,300	25,000
Tons of steel used	8,530	15,000
Plant building dimensions	75 by 305 ft	56 by 418 ft
Plant building area (sq ft)	22,875	23,408
Height of building	52 ft	60 ft
Gathering system (feet)	70,000	121,500
Injection system (feet)	40,900	29,100
Flow station supplying gas	11	12
Injection wells	5	4
Turbines and horsepower	10 of 6000 hp each	12 of 8000 hp each
Total plant horsepower	60,000	96,000
Centrifugal compressors	10	12
No. of compression stages	7	6
Gas compressed for injection	143,000,000 cf/d	300,000,000 cf/d
Gas compressed for fuel	17,000,000 cf/d	28,500,000 cf/d
Compression condensate	2,000 b/d	3,000 b/d
Inlet pressure	11-20 psig	39 psig
Outlet pressure	1,950 psig	1,800 psig
Construction began	February 1953	September 1955
Plant operation began	October 1, 1954	April 17, 1957
Project investment	$20,100,000	$28,000,000



Gas scrubbers and interstage coolers condition gas between the six compression stages of Plant 2. Scrubbers (foreground) will remove some 4000 bbl of liquids daily when in full operation.



Steel columns resting on concrete cross beams support the 12 turbines, gear boxes and compressors. The cross beams rest on 200-ft long reinforced concrete piles driven into the lake bed 85 ft below surface.

from the outlying flow stations and to maintain these small pressure drops, lines as large as 40 in. in diameter are needed. Special studies were necessary to anticipate the problems encountered in handling, weighting and laying such large lines in water depths up to 100 ft.

In addition to the Ulé LPG plant already mentioned, other Creole projects for western Venezuela in the planning stage include a conservation plant in the Bachaquero area.

In eastern Venezuela the San Joaquín, Mulata, Jusepín and Quiriquire fields have compression plants in operation that inject a total of 87 million cu ft of gas daily into the reservoirs. Creole also is participating to the extent of 40 million cu ft of gas injected daily in conservation projects with other companies, and is supplying gas for domestic and small industrial consumption to a distribution company.

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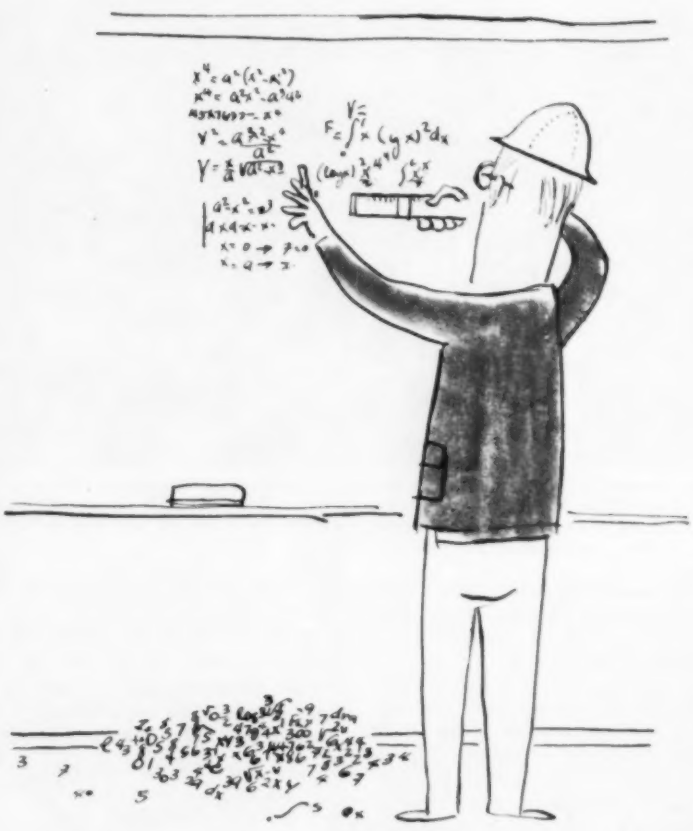
Washington	EXecutive 3-6481
Cleveland	PRospect 1-7827
Galveston	SOuthfield 5-8536

Free Inter Hotel Teletype Reservation Service



Let Merla calculate your next installation . . .

Contact your nearest Merla Representative and let him calculate your next gas lift installation with either conventional outside mounted or wire line retrievable equipment.

Merla Tool Corp. FLeetwood 2-1754, P. O. Box 2576, Dallas, Texas — Clif Mock Co., Houston, Phone OLive 4-2641 — Clif Mock Co., Beaumont, Phone TErminal 8-2814 — Clif Mock Co., Lake Charles, Phone HEmlock 6-8264 — Clif Mock Co., New Iberia, Phone EMerson 9-3626 — Clif Mock Co., Lafayette Phone CEnter 4-1824 — Odex Engineering Co., Odessa, Phone FEderal 7-3568 — Engineering Service Co., Corpus Christi, Phone TUlip 3-4489 — Merla Tool Corp., Oklahoma City, MElrose 2-6983 — Merla Tool Corp., Shreveport, Phone 6-2447 — Production Equipment Products Co., Wichita Falls, Phone 2-5717 — Swan Specialties Co., Casper, Phone 3-4585 — A. Greer Co., Farmington, Phone DAvis 5-3123 — Eastman Oil Well Survey Co., 4002 Macleod Trail, Calgar, Alberta, Canada, Phone 3-3446 — Petroleum Industry Consultants, C. A. Caracas, Venezuela, S. A., Phone 55-70-92.

H. C. Pyle Named AIME's 1958 President-Elect

The American Institute of Mining, Metallurgical, and Petroleum Engineers has announced the nomination of Howard C. Pyle, of Los Angeles, for president-elect of the Institute in 1958.

Grover J. Holt, of Ishpeming, Michigan, general manager of The Cleveland-Cliffs Iron Company, is currently president. Dr. Augustus B. Kinzel, of New York, vice president, Union Carbide & Carbon Corporation, research, is currently president-elect and will become president of AIME at its annual meeting to be held in February 1958, in New York.

Pyle's nomination was presented by the Society of Petroleum Engineers of AIME, the society designated to nominate the 1959 president of AIME. The Society of Mining Engineers of AIME will designate the 1960 AIME president. The Metallurgical Society of AIME will nominate the AIME President for 1961.

Chairman of the AIME Petroleum Branch in 1947, Pyle has been a director of the Institute since 1955. President, director and chairman of the executive committee, Monterey Oil Company, since 1952, he also is a director of the American Petroleum Institute and the Western Oil & Gas Association.

In World War II, Pyle, as a Captain, served on the general staff of General Eisenhower. In Normandy he participated in the coordination of imports of oil.

As vice president of the Bank of America, he was in charge of its oil industry loans from 1945 to 1947. From 1947 to 1950 he was president of Continental Consolidated Corporation, thereafter opening his own offices in Los Angeles as a consultant. In 1951-1952 Pyle was president and director of Jergins Oil Company.

Arthur W. Thornton, of Pittsburgh, assistant to vice president-operations, National Tube Division, U. S. Steel Corporation, has been nominated by the Metallurgical Society of AIME as AIME vice president for one year. He is a past president of that Society and a director of AIME.

Basil P. Kantzer, of Houston, vice president in charge of the Gulf Division of Union Oil Company of California, has been nominated by the Society of Petroleum Engineers of AIME for AIME director for three years. Kantzer will be president of the Society in 1958.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

900 hydraulic horses harnessed for GREATEST FRACTURING POWER!

New BJ SERVICE-CHEMICAL PROCESS 113-ST Fracturing Unit

Now your frac jobs can benefit from a unit with such tremendous power it can inject almost a *half barrel of fluid every second* at pressures up to 1300 psi!

Here's Why You Get Extra Fracturing Power—

1 Each pump is powered by a 600 HP 12 cylinder engine.

2 Highly efficient components, such as an airfoil type variable-pitch fan and two completely new custom-designed rugged transmissions, greatly reduce power losses.

3 The two Gardner-Denver 4½ x 8 triplex pumps (rated at 10,000 psi) are especially designed for high-speed, high-efficiency operation.

4 Dual 3" high pressure fluid lines (rated at 10,000 psi) reduce line losses by over 90% (compared with conventional dual 2" lines).

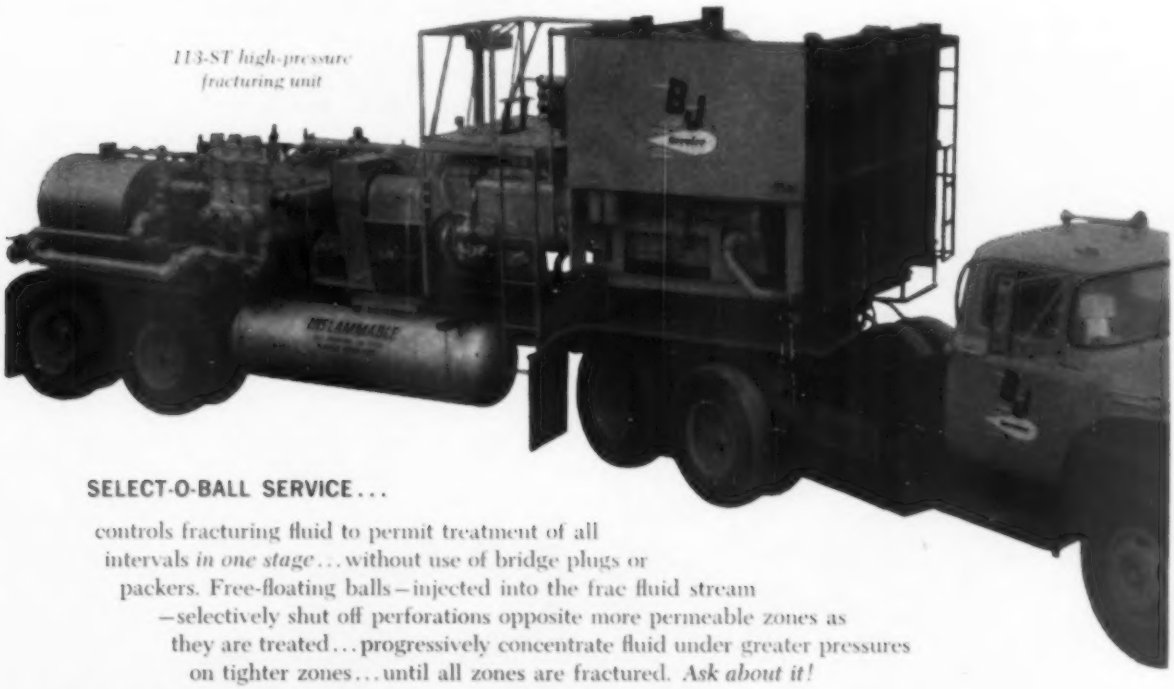
The Result—

1 28 BPM of fracturing fluid at 1300 psi for your high-injection-rate jobs.

2 5¼ BPM at 7000 psi for your high pressure fracturing jobs.

CONTACT your nearest field station for full details.

113-ST high-pressure fracturing unit



SELECT-O-BALL SERVICE...

controls fracturing fluid to permit treatment of all intervals *in one stage*... without use of bridge plugs or packers. Free-floating balls—injected into the frac fluid stream—selectively shut off perforations opposite more permeable zones as they are treated... progressively concentrate fluid under greater pressures on tighter zones... until all zones are fractured. *Ask about it!*

BJ SERVICE, INC. General Offices and Laboratory – Long Beach, Calif.
Stations Throughout California, Rocky Mountain and Permian Basin Areas

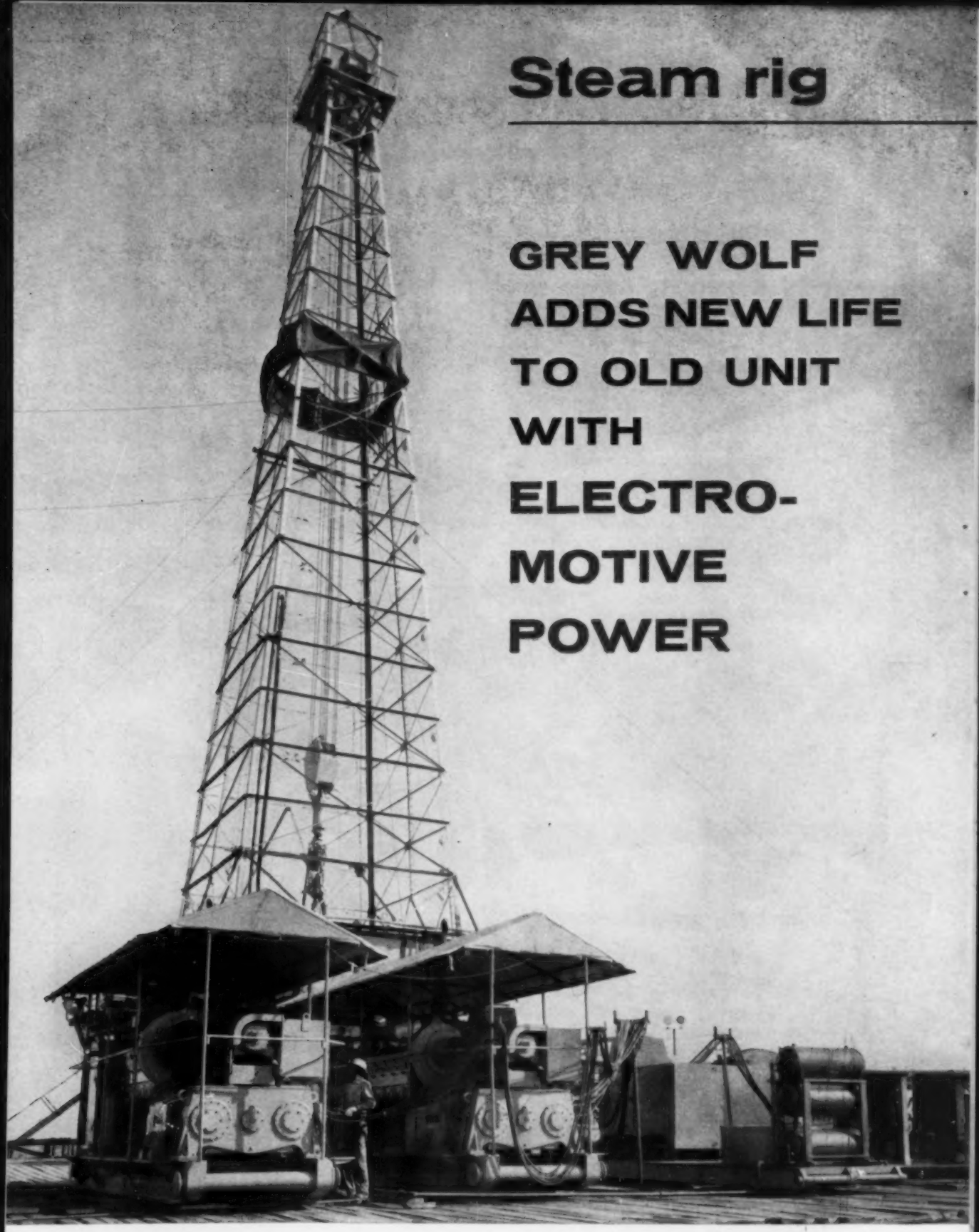
Chemical Process General Offices and Laboratory – Breckenridge, Texas
Stations Throughout the Mid-Continent Area

SUBSIDIARY OF BORG-WARNER CORP.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Steam rig

GREY WOLF ADDS NEW LIFE TO OLD UNIT WITH ELECTRO-MOTIVE POWER



Two skid-mounted Electro-Motive 875-hp generating sets power Grey Wolf's recently converted rig. Each 8-cylinder engine drives two 500-kw dc generators that supply power to electric drive motors on draw works, rotary and mud pumps. Electrical control cabinet is located on skid to right of engines.

converted to Diesel-Electric

Grey Wolf Drilling Company of Houston expects its newly converted Diesel-Electric rig will cut rig-up time to three days—just half the time it took with the old steam unit.

In addition, "trips" are faster with the new rig and drilling speeds were judged faster on two locations where depths up to 13,000 feet were reached. Maximum drilling depth is well beyond 17,000 feet.

Why Diesel-Electric?

Grey Wolf saw two distinct advantages: Diesel-Electric would adapt readily to present components, thus reduce costs; and because components are connected by flexible electric cables, the rig could be broken into skid-mounted packages for fast transport and quick rig-up.

Why Electro-Motive Power?

A "packaged" system was one reason Grey Wolf decided on Electro-Motive Power. For this system is designed and built to work together—one manufacturer—one source of responsibility. Other reasons were the accurate control and torque characteristics of Electro-Motive Power plus its demonstrated economies of long life and low maintenance on both land and offshore rigs.

Have you considered the advantages of Diesel-Electric for your drilling operations? Contact your Electro-Motive Representative for complete details.

ELECTRO-MOTIVE DIVISION
GENERAL MOTORS · La Grange, Ill.
In Canada: General Motors Diesel Limited, London, Ontario
Petroleum Industry Sales Offices: Dallas and Houston, Texas; Morgan City, Louisiana; Los Angeles, California.

View from derrick floor shows simple arrangement of components on ground. Single 625-hp dc electric motors drive mud pumps. Electric cables run from generating units to various motors on overhead runways. Flexible cables permit placing equipment to fit location conditions.

Driller's control stand provides maximum visibility for every operation. Simple, sensitive controls provide smooth and rapid acceleration of loads with positive control of speed and torque. From this one panel, driller has complete control of all Diesel-Electric equipment.

THE BEST WAY TO LOWER

OPERATING COSTS.... LOWER A REDA PUMP INTO YOUR WELL

With investment and labor costs continuing to increase, economy of operation is of paramount importance in producing wells with decreasing oil-water ratios.

Reda-Submergible Pumps are an economical means of producing wells with high fluid volume. Over 80 million barrels of oil have been produced to date from wells previously unprofitable to operate. Not only has production increased, but pumping with Reda extended the ultimate economic life of thousands of wells previously produced at low rates of fluid withdrawal.

Sizes are available to 300 h.p.; capacities from 20 bbls. to 25,000 bbls. per day; depths from 200-feet to over 10,000-feet. Easier, less expensive installation, low operating costs, increased production, greater operating life, and efficient performance lower costs when pumping with Reda.

Write today for further information. Reda engineers will be pleased to furnish complete information.

SIGN OF QUALITY . . . SUBMERGIBLE REDA PUMPS

REDA

PUMP COMPANY

BARTLESVILLE, OKLAHOMA

"X" doesn't always mark the spot . . .

Recommended Oil-Mapping Symbols

API suggests uniformity in oil mapping.

NEW recommended practices for oil-mapping symbols have been published under the central committee on drilling and production practices of the American Petroleum Institute's Division of Production.

Little uniformity in oil-mapping customs exists today. Nearly any of the most common conditions are represented by several different symbols. So wide and varied have these map markings been that reading various company's maps is almost an impossibility without a key. For this reason the API is suggesting that the new standard symbols be applied to new maps and tracing of old maps.

The symbols chosen by the committee represent the most commonly recognized symbols of more than 50 oil and mapping companies. Maximum regard was given to existing customs, the committee states. Presentation of the new symbols does not in any way constitute a recommendation that existing maps be changed to conform, the committee pointed out.

If requests warrant, the Division of Production (300 Corrigan Tower Building, Dallas, Texas) will investigate the practicality of providing pads of adhesive labels, with the standard symbols imprinted, to eliminate the need for drafting the map legend.

Location	○
Abandoned Location	erase symbol
Dry Hole	⊹
Oil Well	●
Abandoned Oil Well	⊹
Gas Well	☼
Abandoned Gas Well	☼
Distillate Well	◐
Abandoned Distillate Well	◐
Dual Completion—Oil	◉
Dual Completion—Gas	◎
Drilled Water-input Well	⌀W
Converted Water-input Well	●W
Drilled Gas-input Well	⌀G
Converted Gas-input Well	●G
Bottom-hole Location (x indicates bottom of hole. Changes in well status should be indicated as in symbols above.)	○---X
Salt-water Disposal Well	⊕SWD

Producing

WITH J&L SUPPLY

The producer's best friend is J&L Supply. J&L stores, sales offices, and a vast network of resident salesmen in the United States and Canada provide active and stand-by service from flush production days through every subsequent phase of recovery. No other organization offers the producer so rich and convenient a source of practical experience and proven equipment.

The technical information, the interest, and the natural enthusiasm of J&L Supply men can be employed to advantage in the selection of casing, as in the design of special strings. J&L Supply service plus the exceptional quality of the product have established for J&L Seamless a remarkable record for satisfactory performance. Casing sizes from 4½" to 13⅜" O. D. Grades H-40, J-55, N-80, and P-110. T & C with API threads. Now also available in Buttress Thread and Extreme Line Joints.

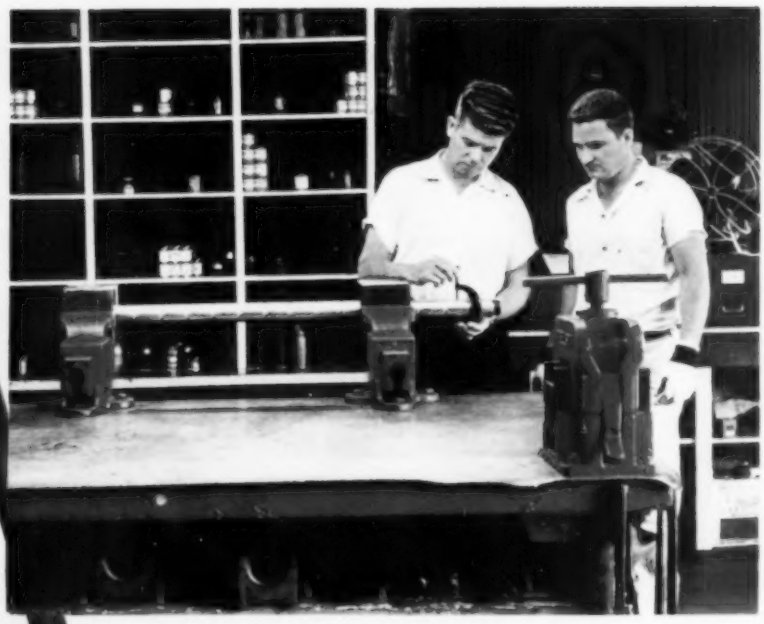
A well has greater promise of trouble-free production when both casing and tubing are J&L Seamless. J&L Supply men stand by 24 hours a day, eager and qualified to be helpful. API tubing 2⅜″ thru 4½″ O. D. Non-upset or external upset. J&L Integral joint in 2⅜″ and 2⅞″ O. D. J-55, N-80, and P-105 grades.

Further logical steps in safeguarding production — Axelson rods, an Axelson pump, and a Cabot unit. J&L Supply men have a vital stake in such a well. They tailor-assemble the pump to fit the job. The rods have been heat treated and normalized from end to end to guard against failure. The Cabot unit incorporates every device of known value for preserving the useful life and promoting the satisfactory performance of rods and pump.

Only a pumping unit with no moving parts, if such a thing were possible, could be more dependable than a Cabot. Cabot design and construction have one objective: steady production with minimum upkeep for the unit and the equipment it activates. Patented rubber tail bearing intercepts fatigue-creating stress. Sykes-cut herringbone gears, flood lubricated. Timken and Hyatt bearings. One-man crank achieves positive balance. Right, powered with a Century motor; a top performing team.

J&L Supply service adds to the downright pleasure of owning a Cabot anywhere in the United States or Canada. Not only are parts immediately available, but J&L men take an active, helpful interest in Cabot performance. Maximum polish rod loads from 3,000 to 32,000 lbs. Standard equipment: floor clearing sub-base, V-belts, belt guards, adjustable slide rails. Left, Cabot's largest unit powered with Type "O" Lorain engine. API walking beam rating 33,160 lbs.; strokes to 144"; API peak torque at 20 S. P. M. 456,000 inch-lbs.

Pump shops are maintained by J&L Supply in the United States and Canada to tailor-assemble an Axelson pump for maximum production on any given job, and to keep that pump in perfect condition for the life of the well. "Never junk an Axelson" is a phrase coined in tribute to the efficiency and complete parts inventories of these J&L pump shops. Pictured here, the shop in Laurel, Mississippi, with J&L Supply men assembling an Axelson Sure-Seal solution to a local production problem.



Production everywhere gets a mighty lift from J&L Supply. Each store profits from J&L production equipment experience throughout the United States and Canada, and is stocked to provide one-stop service geared to the requirements of the area served. You'll enjoy doing business with an organization dedicated for more than fifty progressive years to the customer's logical objective: PRODUCING FOR MORE PROFIT. For real cooperation, get your J&L store on the telephone!

Jones & Laughlin

SUPPLY DIVISION – Tulsa

J&L – A GREAT NAME IN SUPPLIES

36-1

Bethlehem Supply Named Lone Star Steel Distributor

Bethlehem Supply Company, a subsidiary of Bethlehem Steel, has been named a distributor of oilfield casing and tubing manufactured by Lone Star Steel Company, Dallas. According to E. B. Germany, president of Lone Star who made the announcement, the deal is a straight sales arrangement and covers only oil country goods and should not in any way imply that his company is looking toward closer affiliation with Bethlehem Steel.

C. R. Zimmerman, executive vice president of Bethlehem Supply confirmed Germany's statement. "Bethlehem Supply obtains a part of its line of merchandise from a number of independent suppliers; Lone Star is in that category as far as we are concerned, and we are proud to represent this fast-growing young steel mill."

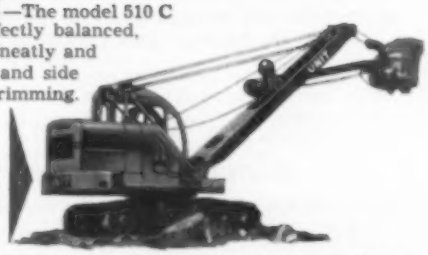
Walter T. Moreland, vice president, sales, for Lone Star, said arrangements already were under way to begin a training program to introduce Lone Star products to Bethlehem personnel, and that pipe will be shipped as soon as it becomes available. He said that while Bethlehem Supply probably will begin receiving small shipments of pipe in the near future, allocations to the new distributor may not become sizeable until Lone Star's new stretch reducing mill and fifth open hearth furnace are completed and in operation. He said increased production created by these installations was the principal reason for adding another distributor.

Bethlehem Supply operates 65 sales offices and stores, mainly in the Mid-Continent oil and gas region. The firm also is represented in the Rocky Mountain area as well as California and Canada. Home office is in Tulsa.

Meet the UNIT Challenger

Model 510 C

AS A TRENCHOE—The model 510 C is powerful, compact, and perfectly balanced, it digs deep . . . trims corners neatly and squarely . . . cuts level floors and side walls without additional hand trimming.



AS A SHOVEL

The model 510 C performs with speed and precision. Has plenty of stability and produces maximum yardage.

ADDED to the UNIT Challenger 3/8 yard line of excavating equipment is the new UNIT 510 C. This crawler type model features: One Piece Cast Gear Case . . . Self aligning Replaceable Hook Shoes . . . Force Feed Lubrication . . . Full Floating Trunnion Mounted Tapered Drums . . . Straight-in-line Engine Mounting with Torque Converter . . . Hydraulic Actuated Clutches and Automatic Traction Brakes . . . Interchangeability of Parts that simplify maintenance and cut costs . . . plus many other advanced engineering features.

And the safety promoting FULL VISION CAB enables the operator to SEE what he is doing at all times. Get all the facts Write for your copy of Bulletin C 900.

UNIT CRANE & SHOVEL CORPORATION
6603 W. Burnham St. • Milwaukee 19, Wis., U. S. A.

Geared to Produce Maximum Yardage

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

A NEW STANDARD OF DRILLING CONTROL
for you with
MARTIN-DECKER ELECTRIC TACHOMETERS

MORE EFFECTIVE MEASUREMENT OF ROTARY RPM, PUMP OUTPUT, AND ENGINE RPM

You will find these new tachometers the most accurate, versatile, and adaptable drilling aids you have ever used for the measurement of rotary-table speed, pump-stroke count, and engine RPM.

ELECTRIC — SELF-ENERGIZING

These instruments have their own generators that transmit low-voltage signals through electric cords to meters installed wherever you need them.

MULTIPLE METERING IS SIMPLE

Now you can have meters as far from the take-off points as you need. You can also have several meters getting their signals from a single source, or a grouping of several meters, each getting its signal from a different pump or engine—or you can have both. Additionally, you can have a simple recorder to make a permanent record of these operations.

CALIBRATE RIGHT ON THE RIG

You can move these instruments from rig to rig, with little concern about the gear ratios used. The pump-stroke tachometer and the rotary-table tachometer each has a screw adjustment that allows you to calibrate the instrument right on the rig. Thus, you don't have to stock different types of tachometers for different types of engines and different types of rotaries.

GET THE FACTS TODAY

Find out how the new design in tachometers can revolutionize the instrumentation on your rig. Write for free literature from the Martin-Decker Corporation, 3431 Cherry Avenue, Long Beach 7, California.

MARTIN-DECKER CORP.
HOME OF THE WEIGHT INDICATOR — LONG BEACH, CALIFORNIA

Smiles of satisfaction are worn by winners E. Carney, Jr., Export Oil Field Sales, high gross Nomad; J. J. Flannery, Link-Belt, high gross guest; W. H. Dickinson, Esso Research & Engineering, longest drive guest; Jerry Brennan, Arthur G. McKee & Company, longest drive Nomad.

THE OASIS—

A gathering spot for NOMADS

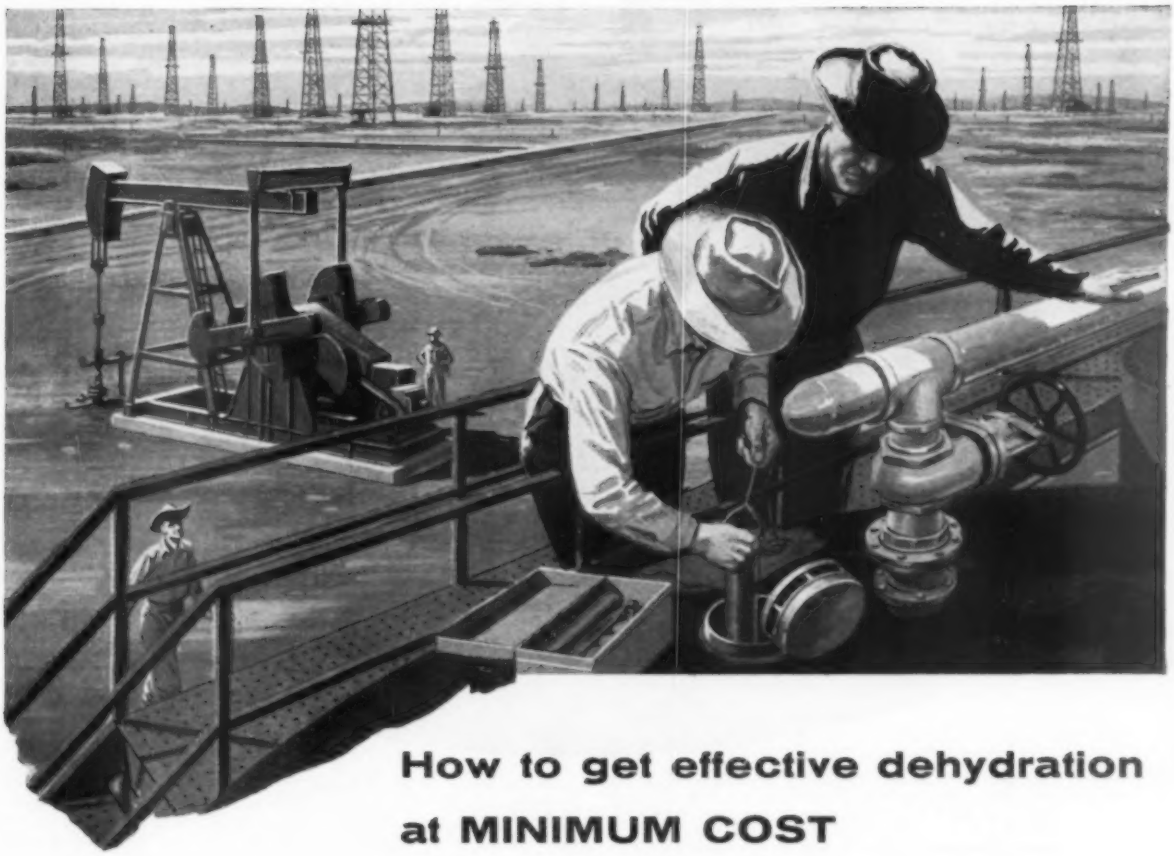
113 Participate in Nomads' New York Golf Party

The New York Chapter of Nomads held its annual spring golf party June 20. This year's party held at the White Beeches Golf and Country Club, Haworth, New Jersey, was blessed by the usual good Nomad weather. Some 113 Nomads and guests played golf while 145 were on hand for dinner.

'Near' winners are W. E. Volkman, Cardwell Manufacturing, nearest pin Nomad; H. Leonard, nearest pin guest; B. Ford, Dorr Oliver, Inc., fewest putts guest; R. E. Kramer, Hammond Iron Works, fewest putts Nomad.

Winners include C. R. Eble, H. P. Sherman Company, low gross runner-up guest; R. T. Meek, Ladish Company, low gross runner-up Nomad; F. G. Shlemmer, Pacific Valves, low net runner-up Nomad; H. Kennedy, Sinclair Oil & Refining, low net guest; F. W. Stopinski, Esso Standard, low net runner-up guest.

Low men on the White Beeches totem pole include J. E. George, Mid-Continent Supply, low gross Nomad; E. E. Benninger, Baker Oil Tools, Inc., low net Nomad and winner of the I. Frank Brown Memorial Trophy; Maurice F. Delano, president New York chapter Nomads; J. S. Moore, Chain Belt, low gross guest.

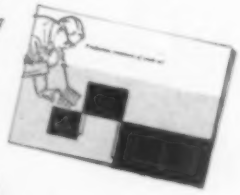


How to get effective dehydration at MINIMUM COST

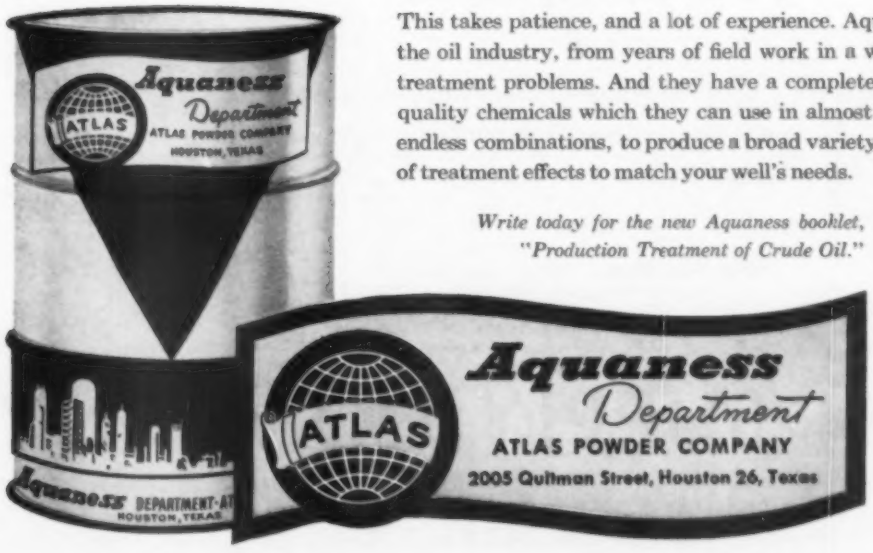
Chemical treatment of crude to bring it to pipeline standards can be an economical, profitable operation—if it's done right.

Aquaness field men work on the principle that there's only one right way to find the best answer to your well's dehydration problem. And that's by working at your well—for days, if necessary—until they get the one combination of chemicals that exactly fits your well fluids and your treating system.

This takes patience, and a lot of experience. Aquaness men know the oil industry, from years of field work in a wide range of treatment problems. And they have a complete line of uniform, high quality chemicals which they can use in almost endless combinations, to produce a broad variety of treatment effects to match your well's needs.



Write today for the new Aquaness booklet, "Production Treatment of Crude Oil."



FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

The emblem pictured above was received with great appreciation by the personnel of Wilson Supply Company. We are very proud of our close association with the Wilson-Snyder Works over this long period.

Wilson-Snyder Pumps, from the very beginning, were noted for their dependable performance. Today, from the smallest to the 1,000 H.P. 818-P, they live up to that reputation — and more.

•

Complete parts for Wilson-Snyder Pumps and expert Pump service men are always available through your Wilson Supply Store.

•

"What You Want — When You Want It"

WILSON SUPPLY COMPANY

1301 Conti Street
HOUSTON, TEXAS

Nomads

Five foreign guests attended the July meeting of the Houston Chapter of Nomads. Shown here are Jack Parks, International Drilling Company, Caracas, Venezuela; Hernando Vasquez of Colombian Petroleum Company, Cuanta, Colombia; and Philipe Exshaw of Cie Francaise des Petroles d'Algerie Oil Research Company, Algiers, Algeria. Two guests not shown are Jean d'Herbes and Francois Gayer, both of Cie Francaise des Petroles d'Algerie in Algiers.

Three new members of the Los Angeles Chapter of Nomads were inducted into the Chapter at the June 12 meeting. Flanked on the left by Bill Brooks of Byron Jackson Tools, Inc., Vice President and Ritual Master, and on the right by Art Marshall of H. C. Smith Oil Tool Co., Member of the Induction Committee, the new members are: Elvin K. Wilson of Shaffer Tool Works (regular member); John P. Davis, Jr. of Technical Oil Tool Corp. (regular member); Peter S. Carberry of Petroleum Week (associate member).

Foreign guests at the June 12 meeting of the Los Angeles Chapter of Nomads. Standing are Glenn S. Prosser of Peters Logging, S. A. from Trinidad; Jerry E. Deevers of International Brown Drilling from France; W. H. May of Santa Fe Drilling from Colombia; Hans Szepanek of Baker Oil Tools from Germany; Lee Corteau of Gulf Italia Company from Sicily; J. M. Wilson of International Brown Drilling from Bahrein Island; Fred Peveto of Texas Petroleum from Colombia and Venezuela; (seated) Earl W. Richardson of D & E from Nigeria; C. M. White of LTS going to Algeria; Ralph H. Connor of LTS to Algeria; Deon Davidson of Baker Transworld from Venezuela; Mack Bell of LTS going to Algeria.

Nomad Meeting Dates and Secretaries

New York Chapter, first Monday of the month, Hotel Roosevelt, New York. Executive Secretary, E. W. Hoeppner, in care of Hughes Tool Co., Room 903, 45 Rockefeller Plaza, New York 20, N. Y.

Houston Chapter, August 12, Grecian Room, Shamrock Hilton Hotel, Houston, Texas. Executive Secretary, Harry E. Estes, P. O. Box 18171, Houston 23, Texas.

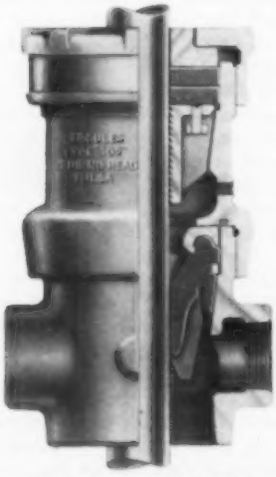
Los Angeles Chapter, second Wednesday, Jonathan Club, Los Angeles, California. Executive Secretary, W. A. Sawdon, P. O. Box 848, Hollywood 28, Calif.

Tulsa Chapter, third Friday, Mayo Hotel. Executive Secretary, E. L. Thomas, P. O. Box 3771, Tulsa 9, Okla.

Dallas-Fort Worth Chapter, first or second Monday. Secretary, R. B. Gilmore, DeGolyer & MacNaughton, 5625 Daniels, Dallas, Texas.

there's a Hercules tubing head

TO FIT YOUR REQUIREMENTS...

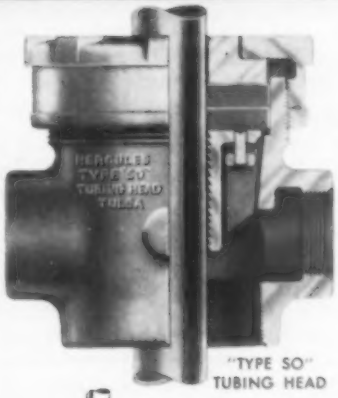


"TYPE SOS" TUBING HEAD

HERCULES "Type SO" Tubing Head is particularly suited for pumping due to compactness (only 12½" high). Stripper rubber can be used in body for running or wiping tubing. Also ideal for intermittently flowing wells.

HERCULES "Type SO" and "SOS" Tubing Heads are the favorite of successful operators because of their simplicity, ruggedness and ease of operation. Available in 4½" OD to 7" OD Casing Sizes to suspend 2", 2½" or 3" tubing. Constructed from pressure cast steel and tested to 4,000 PSI. Slips are hinged for ease of installation and positive alignment.

HERCULES "Type SOS" Stripper Tubing Head is unsurpassed for use in well servicing operations as well as on flowing wells. It consists of a HERCULES "Type SO" Tubing Head with a bowl and Neoprene Tubing Stripper.



"TYPE SO" TUBING HEAD

HERCULES TOOL Company

"MANUFACTURERS OF OIL FIELD EQUIPMENT SINCE 1924"

GENERAL OFFICES AND PLANT TULSA, OKLAHOMA

Available through all supply stores: Export Representative: Oil Field Equipment Co., Inc., 30 Church Street, New York 7, N. Y.

EXPLORATION ACTIVITIES

OKLAHOMA

★ A 4200-ft Arbuckle test for Jefferson County is underway by Cities Service Oil Company. The test is Swan No. 1 located on a 3450-acre block 15 miles northeast of Waurika. Nearest production is in the Loco field, four miles to the north. The test is in the center NW NW SW Sec. 5-4s-5w and is a joint venture shared with Sunray-Mid-Continent. Cities Service is the operator with an almost 84 percent interest.

★ A new gas pool has been opened by Carter Oil Company at a rank wildcat in northeast Kiowa County. The company's No. 1 McDonald, about five miles northwest of the Southwest Carnegie pool, flowed at a rate of 3,500,000 cu ft per day on a one-hour drill-stem test in the Simpson at 3319-55 ft. Recovery was 100 ft of gas-cut mud. Initial flow pressure was 485 psi; final flow pressure was 555 psi, and shut-in bottom-hole pressure was 1450 psi after 30 minutes. Hunton was topped at 2166 ft, the Sylvan at 2241 ft and the Viola at 2505 ft.

NORTH DAKOTA

★ New depth record for the state has been set at Amerada Petroleum Corporation's No. 9-A S. D. Unit in Williams County. The geological wildcat, located in NW SE SW 16-156n-95w, is drilling below 14,200 ft toward a Pre-Cambrian objective at about 14,400 ft. Old record, also held by Amerada, was at the No. 2 Kvam in the Beaver Lodge field in Williams County. It was abandoned as a dry hole in the Madison lime at 14,056 ft.

UTAH

★ A rank wildcat of Sevier County, in the central part of the state is being reentered for the second time this year by Standard Oil Company of California. The well is the No. 1 Sigurd Unit, which had stopped at 9638 ft. Shell is now slating the test to go to 14,000 ft. Cores were taken at several intervals in earlier drilling although nothing commercial was reported. The well is more than 30 miles from production.

PARAGUAY

★ International Products Corporation has announced the conclusion of an agreement with the Government of Paraguay under which International Products has received an oil exploration and exploitation concession covering 750,000 acres in the Chaco region along the Bolivian border. The acreage is adjacent to oil fields in Bolivia on which there are already proved producing wells. The Glenn McCarthy concession, close-by in Bolivia and on which oil and gas have reportedly been found, has been optioned to four leading United States oil and gas companies. Also in neighboring Bolivia, the Bolivian Gulf Oil Company is scheduled to drill its first well on its concession by late summer or early fall.

WASHINGTON

★ Standard Oil Company of California, Western Operations, Inc., has begun an exploratory well in the Rattlesnake Hills of Benton County, eastern Washington. The wildcat well, Rattlesnake Hills Unit No. 1, will probe for gas and/or oil to a depth of about 8000 ft on a site 15 miles north of Prosser. (on Sec 15 T11N, R24E). Company spokesmen stressed the well is in an area where little is known of the subsurface. Nearest modern drilling to date has been Kirkpatrick No. 1, Standard's stratigraphic test well near Condon, Oregon, 100 miles south. This test is still being drilled, below 8700 ft. Drilling contractor on the assignment is Miracle-Wooster, now drilling Kirkpatrick No. 1.

LOUISIANA

★ A Miocene sand discovery, the Lone Star Producing Company No. 2 Godchaux Sugars, Inc., has been completed in Lafourche Parish for a daily flowing potential of 480 bbl of 37.5 deg oil. Gas-oil ratio was 492 to 1. Completion was through 9/64 in. choke. Flowing tubing pressure was 4425 psi. Completion was through perforations 13,383-396 ft and 13,404-413 ft. Louisiana Conservation Commission records show that the No. 2 Godchaux Sugars is the second largest oil well completed in the Commission's Houma District. The discovery was given a daily allowable of 176 bbl.

★ A pool opener has been announced by Shell Oil Company in the Chauvin area 2½ miles northeast of the South Houma field in Terrebonne Parish. The find is the No. 1-A Peters, 64-18s-18e, which produced on initial test at the rate of 141 bbl of condensate per day through 12/64-in. choke from 11,282-306 ft. Gas-liquid ratio was 26,000 to 1.

★ In Lafourche Parish The California Company has completed a new pay find in the Cut Off area. The company's No. 2 C. F. Bailey, 60-17s-21e, flowed 171 bbl of oil per day through 9/64-in. choke from 11,180-200 ft with a gas-oil ratio of 444 to 1.

ARIZONA

★ A rank wildcat is underway in Mohave County, in the northern part of the state. Operators are Paul Poteet and Tony Lyons. Test is the No. 1 Federal, in C SW NW 14-39n-6w. Objective is the Coconino around 2500 ft.

KANSAS

★ Lion Oil Company Division of Monsanto Chemical Company has completed the Hoeme No. 1 as an oil discovery in Pratt County. The well, on a lease wholly owned by the company, is flowing oil at the rate of 120 bbl per day through an 18/64-in. choke. Completion was in the Simpson formation through perforations from 4350 to 4356 ft. Drilled in the NW ¼ of the SW¼ of section 17, township 27S, range 12W, the discovery well is about four miles northeast of the city of Pratt. It is located on a 1540-acre block of leases owned by the company. Drilling has begun on a confirmation well east of the discovery.

TEXAS

★ Discovery of a promising new oil field in the North Wemac area of Andrews County, about three miles east of Andrews, was announced recently by Continental Oil Company, with completion of the T. F. Teague No. 1, which flowed at the rate of 1345 bbl a day on a ½-in. choke. The wildcat well was drilled to 13,520 ft in the Wolfcamp formation. Nearest producing well is two miles south of the discovery well. Conoco has a block of 1760 acres in the area.

★ A new field has been opened in Young County, North Texas, at the Stephens Oil & Gas No. 1 Boozer, a mile northeast of the South Bend townsite and about a mile southwest of shallow production. Pay is from the Bend conglomerate at 4003-7 ft. On drill-stem test at that depth, there was a blow of gas, and after crews had pulled 40 stands of pipe, the well started flowing. It flowed out of control for 20 hours. Crews set up dikes to retain flowing oil, with some 2500 bbl saved. Well was killed and crews conditioned hole and were last reported drilling ahead toward a contract depth of 4600 ft.

★ In Harris County, field limits of the Mykawa field have been extended nearly a mile north with successful completion of Jack Perry's No. 1 Hostetter. The well flowed 37,500,000 cu ft of gas per day from perforations at 8332-38 ft. Gas-liquid ratio was 33,400 to 1.

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Exploration

TEXAS (cont.)

★ Best production yet found off the Lower Texas Gulf Coast has been indicated in a new and shallow pay zone in the offshore Chevron field of Kleberg County. The find is Standard Oil Company of Texas No. 947-55, drilled vertically to 7003 ft. Casing was perforated at 6827-47 ft. On a three-hour test, the well flowed 32 bbl of condensate, with 1,100,000 cu ft of gas per day. The well has been shut in pending completion of other wells in the block. Kerr-McGee is the contractor on the block and has started an offset directional hole, with contract for 7500 ft.

CANADA

★ Two test wells are to be put down in a submerged area on the Canadian side of Lake Erie. Wells will be drilled by Imperial Oil Ltd. and Harvest Petroleums Ltd. under a combined license. Location of the two wells are in a 16 sq mile area near Pelee Point in Essex County, Ontario. Contract with the government calls for wells to probe sand at 1400 ft.

★ Deep wildcat in the Foothills Belt of Alberta is getting underway by Shell Oil Company. Test is the No. 1 Panther, scheduled to go to 12,000 ft. Location of the well is 1¼ miles east of the 36,000-acre Panther River reservation which is leased to Union Oil Company of California and Canadian Homestead Oils Ltd. These two companies will make a contribution of dry hole money and share access roads with Shell. Shell's No. 1 Panther is expected to confirm structural geology of Union's and Canadian Homestead's No. 12-11 Panther River wildcat, which suspended operations at a depth of 8063 ft in March due to Alberta road conditions. A core in this well indicated a possible gas-bearing formation.

CALIFORNIA

★ Humble Oil & Refining Company heads a long list of operators setting up new deep tests in the state during July. Humble is drilling a 14,000-ft test southwest of Piru, in Ventura County at its No. 1 Charles S. Johnson, in 30-4n-18w.

★ Shell Oil Company has spudded the No. 1 Shell-Sunray-USL, a wildcat in 2-3n-19w, in the Wiley Canyon area of Ventura County. Well has a 10,000-ft objective. Test is 1½ miles west of the Western Gulf Oil Company No. 4 Hunter, that opened a pool at 8712-55 ft making 15 bbl of condensate and 1,545,000 cu ft of gas daily.

★ Operations have begun on the "M. V. Torry," General Petroleum Company's coring vessel, in water over submerged lands owned by the City of Los Angeles. Vessel is operating about a mile offshore from the foot of Venice Blvd.

★ Oil and gas development on a 3500-acre tract of tidelands owned by the City of Hermosa Beach has been tentatively approved for drilling by Shell Oil Company. The approval, however, is subject to public referendum this fall. Proposal amounted to $11,000,000 and provides Shell with exclusive rights to drill and produce oil on the tract for 35 years; agreement with the City Council also calls for a $500,000 bonus to the city. Tract extends three miles offshore in water depths up to 400 ft and is on the northwestern end of the Seal Beach-Wilmington-Torrance-Redonda oil fields. If referendum results are favorable, operation is expected immediately with exploratory wells being drilled from a newly-completed mobile floating drilling barge.

★ Caltex Land & Development Company has extended the Cowchilla gas field one-half mile at the company's No. 2-6 Southern Realty. Extender is located in section 6-10s -14e, Madera County. Flow was at an initial rate of 4,000,000 cu ft per day through 19/64-in. choke from perforations at 7995-8010 ft. Contractor on the hole was Miller & York.

★ On their offshore Summerland lease acquired by bid last January, Standard Oil Company of California and Humble Oil and Refining Company have recently abandoned their second core hole. These core holes, which were drilled from the mobile barge "Pacific Driller," were designed to obtain geologic information. The first hole was drilled to a depth of 8454 ft and the second to 7389 ft, both bottoming in the Sespe formation. Consideration is now being given to the construction of a platform for the purpose of drilling one or more test wells on the lease.

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CUBA

★ A deep wildcat has been set by Siboney-Caribbean Petroleum Company on the southern coast of Cuba in Camaguey Province. Operations are believed underway with hole depth set for 10,000 ft to the Middle Cretaceous. Location is on a block of 1,382,000 acres held by Siboney-Caribbean. Hudson Oil and Gas Company of Shreveport, Louisiana, and Cuban Stanolind Oil Company of Tulsa, Oklahoma, share in the joint venture.

FRANCE

★ The Societe des Petroles de Valence plans to drill a first deep test well in its Luberon licence area, north of Marseilles, this autumn. In the Valence Basin, as already announced, the company is to drill a second test well at Montmiral now that the first well at St. Lattier has been completed.

AFRICA

★ In French West Africa the Societe des Petroles du Senegal is continuing intensive geophysical surveying which, it is hoped, will lead to a location being chosen in Southern Senegal for deep test drilling later this year.

★ The third well drilled at Afam, 20 miles east of Port Harcourt, Nigeria, where British Petroleum and the Royal Dutch Shell Group are associated in oil exploration activities, has encountered oil. The first Afam well discovered oil at the end of last year, but Afam No. 2, completed three months ago, was a dry hole.

WYOMING

★ First commercial producer has been completed in the central portion of the Powder River Basin. The new Parkman zone discovery is Farmers Union Central Exchange No. 1 Government-Ferguson, in the Dead Horse Creek area of Campbell County. The well pumped 329 bbl of oil and 58 bbl of bs&w a day from perforated zones at 6968 to 7088 ft. Company is beginning the No. 1 Government-Haberland as a southeast offset to the discovery.

GUATEMALA

★ Sloan Exploration Company, Houston, Texas, is now drilling the first of a series of wells in the eastern section of the Central American country. Sloan, which holds four concessions totaling 124,000 acres, has been conducting geophysical work in Guatemala during the past two years. First drilling location in the company's Morales concession, with the well spotted about 20 miles west of Puerto Barrios. A rig capable of drilling to 7000 ft is being used in the project, although operators expect to encounter first potential oil and gas zones at about 1900 ft.

JORDAN

★ Drilling of the Arab country's first well was begun July at a location 35 miles southeast of Amman. Operations were formally set in motion by King Hussein. Test is being drilled by Edwin Pauley, of Los Angeles, California, who has been granted the Jordanese concession.

NEBRASKA

★ Scottsbluff County has its first successful well in the completion of Tom Vessels Jr. and Strain Drilling Company's No. 1 State, six miles east of the town of Gering and 12 miles north of the nearest oil well in Banner County. On test of the "J" sand, the wildcat pumped 109 bbl of oil per day from perforations at 5683-92 ft. In the drilling phase, a drillstem test of the same zone recovered 1237 ft of oil.

ALABAMA

★ Seventeen wildcat operations were reported active in the state during the month of July. Deepest test is Humble Oil & Refining Company's No. 1 Chaplin-Kelefac, coring below 11,600 ft. Location of the prospector is 3 miles northwest of Rockville in Clarke County, C NE NW 4-5n-2e.

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What's doing in DRILLING

★ **The drillbit goes deeper.** In state after state drilling depth records continue to fall. In Oklahoma, Big Chief Drilling Company set a new state record for Magnolia Petroleum Company by drilling below 18,434 ft the No. 1 Sterba-Ordovician, a geological wildcat in the Cement field in Caddo County. This breaks the nine-month old record of 18,158 ft set at Frankfort Oil Company's No. 1 Pruitt, west of the Chickasha field in Grady County, Oklahoma. Big Chief's contract with Magnolia schedules drilling to 20,000 ft in the new title holder. How long this well will remain the Sooners' deepest may be measured in months, since other operators are getting underway with tests slated to go to 22,000 ft.

★ **Helmerich & Payne, Inc.,** Tulsa, Oklahoma, is entering foreign drilling operations. The company has purchased Sinclair Oil & Refining Company's entire drilling operation in Venezuela at a price exceeding a million dollars. In the transaction, Helmerich & Payne received five rigs in addition to warehouses, trucks, bulldozers, inventory stock and other equipment. The rigs (two steam, two diesel, one intermediate diesel) are now operating in the Barinas area. One of the rigs, capable of 15,000 ft drilling, will soon be moved to the Maturin Basin in eastern Venezuela, officials say. Helmerich & Payne now operate 21 deep drilling rigs in the U. S.

★ **A & A Drilling Company** has been formed in Fairfield, Illinois, by Alva C. Davis and Howard Simcox. The firm is operating two rotary rigs. Another new firm, in conjunction with A & A is the Alva C. Davis Exploration Company, owned by Davis, Simcox, and Jack Freud.

★ **Kermac Drilling Company of Venezuela,** a new subsidiary of Kerr-McGee Oil Industries, Inc., has been contracted to drill for two groups of American companies in Lake Maracaibo, Venezuela. A drilling tender, sent from the Gulf Coast of Texas last month is already on location for a group headed by Sun Oil Company. A second tender is expected to begin work September 1 for a group of companies, with Phillips Petroleum Company acting as operator. This new venture represents Kerr-McGee's first new foreign drilling operation in four years.

★ **Drilling in Argentina** may be in sight for Laughlin-Porter Drilling Company of Midland,Texas, if contractual negotiations are completed. The firm is bidding for contracts with the Argentine government to drill 40 oil wells in Tierra del Fuego, an island territory at the southernmost tip of South America. The land is bounded on the north by the Straits of Magellan and on the south by Cape Hope. It has been made clear that the contract is for the drilling of wells for the government oil company and is not receiving a concession.

★ **El Paso Natural Gas Company** has purchased the five rotary rigs of L. H. & S. A. Olson Drilling Company, Midland, Texas. Also involved in the sale were 89 producing wells in West Texas owned by the Olson firm and W. R. Weaver. Consideration was reported to be approximately $4,925,000.

★ **Zapata Off-Shore Company's "Scorpion"** has set a new time record for relocation of a mobile platform in the Gulf of Mexico. Within an 8½-hour period beginning shortly after dawn, the three-legged electrically-driven unit was lowered to the water and towed approximately one mile to a new location, then raised again to a height of 25 ft above the water. Depth of water at both old and new locations was reported to be about 62 ft. The "Scorpion," which has been in operation a little more than a year, made its fast move in a silt-bottomed area 10 miles out from the South Pass of the Mississippi River, approximately 30 miles east of Venice, Louisiana.

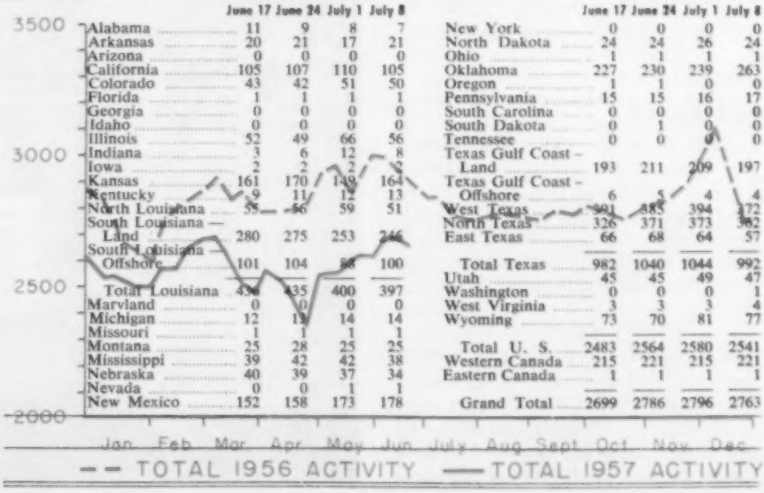
★ **Believed to be the first** air-conditioned drilling rigs for land use, a rig built for Camdrill International, Inc. and assembled in Houston, Texas, is now ready for export. The rig will be sent to North Africa where it will be operated in the desert at heats ranging up to 130 F. The rig floor is to be enclosed, and together with the engine house, will be cooled by six evaporative-type units employing water from a well to be drilled in the desert. The units will displace 33,000 cu ft of 80 F air per min in some 20,000 cu ft of space. Camdrill's rig will be in use for Mobil Oil Company of Canada, Ltd.

★ **A new Gulf tidelands drilling contracting firm,** Louisiana Delta Offshore Company, has elected Dave E. Vasser as president. Alvin H. Howard is chairman of the board and H. A. Broughton is superintendent of drilling.

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

	June 17	June 24	July 1	July 8
Alabama	11	9	8	7
Arkansas	20	21	17	21
Arizona	0	0	0	0
California	105	107	110	105
Colorado	43	42	51	50
Florida	1	1	1	1
Georgia	0	0	0	0
Idaho	0	0	0	0
Illinois	52	49	66	56
Indiana	3	6	12	8
Iowa	2	2	2	2
Kansas	161	170	149	164
Kentucky	9	11	12	13
North Louisiana	55	56	59	51
South Louisiana — Land	280	275	253	246
South Louisiana — Offshore	101	104	88	100
Total Louisiana	436	435	400	397
Marvland	0	0	0	0
Michigan	12	13	14	14
Missouri	1	1	1	1
Montana	25	28	25	25
Mississippi	39	42	42	38
Nebraska	40	39	37	34
Nevada	0	0	1	1
New Mexico	152	158	173	178
New York	0	0	0	0
North Dakota	24	24	26	24
Ohio	1	1	1	1
Oklahoma	227	230	239	263
Oregon	1	1	0	0
Pennsylvania	15	15	16	17
South Carolina	0	0	0	0
South Dakota	0	1	0	0
Tennessee	0	0	0	0
Texas Gulf Coast — Land	193	211	209	197
Texas Gulf Coast — Offshore	6	5	4	4
West Texas	391	385	394	372
North Texas	326	371	373	382
East Texas	66	68	64	57
Total Texas	982	1040	1044	992
Utah	45	45	49	47
Washington	0	0	0	1
West Virginia	3	3	3	4
Wyoming	73	70	81	77
Total U. S.	2483	2564	2580	2541
Western Canada	215	221	215	221
Eastern Canada	1	1	1	1
Grand Total	2699	2786	2796	2763



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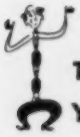

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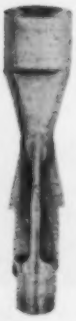

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Drilling

★ **Oil well drilling contractors** have been urged to take into account in bid estimating the higher replacement costs of steel tubular goods and equipment resulting from recent hikes in basic steel prices. In a letter to members of the American Association of Oilwell Drilling Contractors, C. H. Todd, chairman of the accounting committee, called attention to the predicted 7½ to 10 percent increases in the costs of steel goods used in drilling. Todd is president of The R. W. Rine Drilling Company, Wichita, Kansas. "The basic price of steel was advanced last week by at least $6 per ingot ton, which amounts to about 4 percent on the total price of steel," Todd said. "Since drilling contractors have been operating on an extremely narrow profit margin for years and have been constantly absorbing various phases of increased drilling costs, too much emphasis cannot be placed on the necessity for taking into consideration the most recent steel price increases in all future bidding practices."

★ **The second of four** drilling tenders constructed for Perforaciones Delta of Caracas, Venezuela, was recently commissioned in Houston, Texas, and another will be commissioned in the near future. The "Delta IV" was commissioned only 90 days after keel laying and 21 days after launching the 1320 gross ton vessel. At the ceremony were Joe Zeppa, president of Delta; Mark Gardner, Delta vice president, and George Stetson, Delta chief engineer. "Delta IV" measures 180 by 74 ft and features a 60 by 80 ft helicopter deck, a completely equipped work shop, a generator room with three diesel driven 60 kw generators, office, galley, and crew quarters for six men.

★ **Studies of blowout prevention** training have been initiated by a special subcommittee of the American Association of Oilwell Drilling Contractors. Headed by J. U. Teague, president of Columbia Drilling Company, Houston, and AAODC national vice president, the group has begun work on developing a method and program for training toolpushers, drillers and crewmen. Subjects to be covered in the training course include causes and prevention of blowouts, and types and operation of blowout preventer equipment. "A recent survey made by an oil operating company shows that there is very little material available on these subjects," Teague said. "Also, no effort has been made to gather the existing material on blowouts or prevention equipment operation, or to put this information into usable form. This, also is the purpose of this committee."

★ **San Joaquin Drilling Company, Inc.** is being dissolved. J. H. Harris and E. E. Whipple, co-owners of the company, are continuing in the oil well drilling business as owners and operators of The Sun Drilling Company, and Sun Marine Drilling Corp. Dissolution of San Joaquin Drilling will result in simplified management procedures and improved service in the two remaining concerns of the group, owners say. Five complete drilling rigs of the San Joaquin Drilling Company, Inc. have been purchased by Republic Supply Equipment Company, a wholly owned subsidiary of The Republic Supply Company of California engaged in the purchase, sale and rental of used drilling equipment as well as the sale and distribution of new drilling machinery and components.

★ **Falcon Seaboard Drilling Company** reports that 26 of the firm's 28 rigs are drilling on company or contract work. Another rig is also being added to its drilling operations. A new rig is being shipped to Boyuibe, Bolivia, for the drilling of Bolivian Gulf Oil Company's first wildcat in the joint concession there. Adding to the firm's activity, the Venezuelan subsidiary, D & D Drilling Company, is continuing full scale drilling and workover operations in eastern Venezuela. D & D was purchased recently upon completion of Falcon Seaboard's $3,375,000 public financing program.

★ **A newcomer,** the recently-formed Producers' Drilling Company has entered the quest for offshore oil by launching its first drilling barge in Orange, Texas. Slated for shallow-water drilling in the waters of southern Louisiana, the submersible barge is the "W. F. Youngblood," named for the new drilling company's vice president and general manager. Youngblood is the former assistant drilling superintendent for Penrod Drilling Company. Producers' president is J. L. Goldman.

The slotted-type barge will drill to depths in excess of 20,000 ft. Initial drilling location will be near the mouth of the Mississippi, where it will drill in 14 ft of water for Continental Oil Company.

★ **Drilling Business,** impressive new company publication of Loffland Brothers Company, points several facts about the largest drilling contractor in the world. First issue depicts the scope of the company's worldwide operations. In South Louisiana, for example, Loffland has drilled 6,000,000 ft of hole in the past five years – an amount comparable to the distance between New York City and Dallas. That's a lot of hole.

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RUNNING TOUR with MEN in the INDUSTRY

Walter E. Smith has been named purchasing agent for The British-American Oil Producing Company. The promotion came concurrently with the retirement of **Jack H. Wolfe.** Smith was formerly assistant purchasing agent.

A. F. Childers Jr., formerly president of Toklan Oil Corporation of Tulsa, has been elected vice president of Gulf Coast Leaseholds, Inc. Before joining Toklan, Childers was for several years with Cecil Hagen and Associates, a Houston geological consulting firm. He spent 17 years with Gulf Oil Corporation as a petroleum geologist and valuation engineer before his association with Hagen.

Roger Wiley has been named chief geologist of Kirkpatrick and McGuire, Shreveport petroleum engineers and oil property operators. With United Gas the past eighteen years, Wiley was a geologist with Union Producing Company just prior to his accepting the new post.

Roger Wiley

A. E. Woerheide Jr.

A. E. Woerheide Jr. has been named chief engineer for Stekoll Petroleum Company. Woerheide was previously employed by Byrd Oil Company as vice president in charge of production and drilling. As chief engineer he will be in charge of the engineering on development work, reservoir studies and exploration.

The board of directors of Sinclair Oil & Gas Company, producing subsidiary of Sinclair Oil Corporation, has announced a series of executive promotions. The executives promoted are:

H. B. Smith, since 1953 president of Sinclair Oil & Gas Company, elected chairman of the board and chief executive officer to succeed **H. L. Phillips,** who will continue as a director. **W. H. Morris,** vice president, Sinclair Oil Corporation, and formerly president, Sinclair Pipe Line Company, elected president to succeed Smith. He also was named a director. **J. W. Jordan,** executive vice president of Sinclair Oil & Gas Company, elected vice chairman of the board of directors. Executive officers for administration and operations also were named, following the plan instituted by the parent company. **J. N. Johnson,** vice president and assistant to the president, elected executive vice president for administration, a newly-created position. He also becomes a director. **J. B. Kennedy,** a director, vice president and manager of the Houston division, elected executive vice president for operationse, also a newly-created post. He will be transferred to Tulsa. **D. R. Gearhart,** vice president and a director of Sinclair Oil & Gas who recently was elected president of Sinclair Canada Oil Company, will continue in charge of all Sinclair exploration and production in Canada. **F. H. Rhees,** vice president and a director of Sinclair Oil & Gas, will continue in charge of widespread production activities for the company.

Election of a new vice president of Sinclair Oil & Gas Company and the assignment of three men to new management posts, have been announced. **G. D. (Dan) Almen Jr.,** vice president and manager of the offshore division at New Orleans, Louisiana, has been named manager of the Houston division. **R. A. Wright,** assistant to the president assigned to the offshore division, has been elected vice president and manager of the offshore division. He was assistant division manager of the Denver, Colorado, division. **Dick T. Fenwick,** executive assistant in Sinclair's production department in Tulsa, has been named assistant division manager of the Denver division, succeeding Wright.

C. O. Hopper has been named division drilling superintendent for Pan American Petroleum Corporation's Canadian division, and new district and field superintendents have been named at the firm's Alberta and Pembina offices. **W. M. Jones** has been promoted to district superintendent of the Alberta district, and **W. M. Bogert** was promoted to field superintendent of the Pembina producing area.

Walter H. Williams Jr. has been named to the Oklahoma City engineering staff of Tekoil Corporation. Williams was associated with Stanolind Oil and Gas Company in Oklahoma and Kansas for nine years prior to joining Tekoil.

W. C. Dennis has been named chief geologist and **Tom L. Clifton** land manager for Lion Oil Company, a division of Monsanto Chemical Company. Dennis has been regional geologist for the company at Shreveport, Louisiana. He replaces **E. D. Klinger** who recently retired and has entered the consulting field, with offices in Shreveport. **Stone Schuler,** assistant land manager, and **Jesse Perkins,** company drilling superintendent have retired. Schuler has his headquarters in El Dorado; and Perkins was most recently located at Lafayette, Louisiana.

E. D. Klinger

F. H. Wilson

F. Hugh Wilson, formerly of Houston, Texas, has been appointed exploration manager of Tidewater Oil Company's western division with headquarters in San Francisco. Wilson replaces **Henry H. Neel** of Burlingame, California, who has been promoted to the newly created job of manager of foreign exploration for the International Oil Company. **Edd R. Turner Jr.,** has been appointed divisional geologist of the southern division of Tidewater in Houston, succeeding Wilson. Prior to his appointment, Turner was exploitation geologist.

John C. Hostetler, consultant and specialist in oil property management and waterflooding, has organized Hostetler Engineering with headquarters at Monahans, Texas. **T. G. Ward** is chief engineer and head of the staff. Hostetler has been a partner in Buckles and Hostetler, production consulting firm of Monahans.

J. C. Hostetler

B. W. Croft

B. W. Croft, assistant manager of Mountain Fuel Supply Company's producing division at Rock Springs, Wyoming, has been appointed manager of the producing division. He succeeds the late D. K. Bowen. His headquarters will be at Rock Springs.

George Echols of the Standard Oil Company of Texas will take office in December as president of the National Oil Scouts and Landmen's Association. Other officers are: **Walter B. Holly,** Lion Oil Division of Monsanto Chemical Corporation, first vice president; **J. B. Johnson,** Sohio Oil Company, second vice president; **C. R. Kelly,** Sun Oil Company, third vice president; **Dan B. Green,** Magnolia Petroleum Company, secretary-treasurer, and **George Ross,** Humble Oil & Refining Company, editor-in-chief.

Robert B. Capps has been named division manager of the southern division exploration office of Kerr-McGee Oil Industries, Inc., in New Orleans. Capps has been for the past three years a staff geologist in the company's Oklahoma City headquarters.

Preston A. Peak, Dallas, Texas, has been named vice president of Oil and Gas Property Management. Peak is a graduate of the U. S. Naval Academy and of Wharton School of Finance.

H. L. Hesselmeyer has been appointed manager, gas, producing department, Standard Oil Company of California, Western Operations, Inc. He succeeds **R. E. Clarke** who recently was named manager, natural gas utilization. **J. E. Mahle** was named drilling superintendent, northern division, Taft, succeeding **C. V. Reynolds,** who has retired. **Carl Johnson** becomes assistant drilling superintendent, northern division, Taft, filling the position Mahle vacated. Johnson formerly served as drilling foreman.

Sol Meltzer and **Donald G. Wright** of Calgary, Canada, have been named to the newly created posts of district exploration geologist and **Bernard J. Kelly** of Calgary has been appointed district geologist for Canada-Cities Service Petroleum Corporation. Meltzer will be exploration geologist for the western Alberta and British Columbia district of Canada. He has been serving the past five years in Calgary as exploration geologist. Wright will serve as exploration geologist in the eastern Alberta, Saskatchewan and Manitoba district. He, too, has been in Calgary for five years, serving as geologist and geophysicist.

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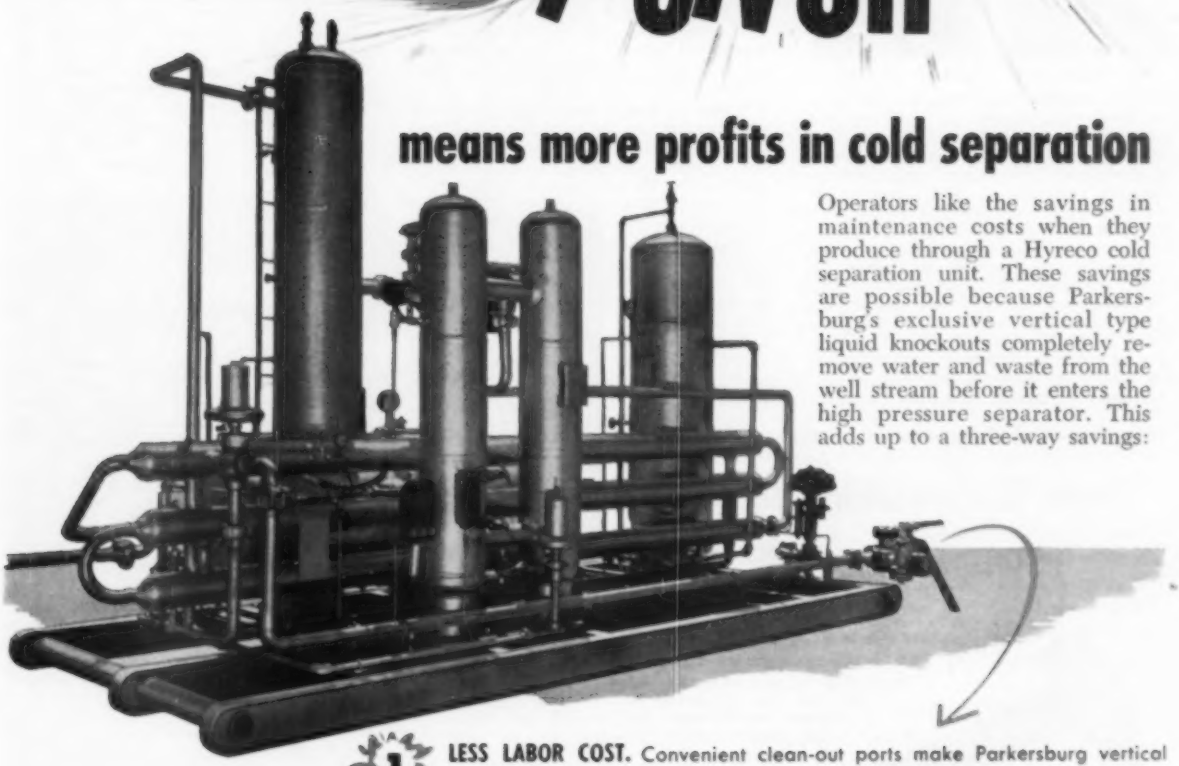

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Henry H. Neel has been named to the newly created post of manager of foreign exploration of Tidewater Oil Company.

A graduate of Stanford University, Neel joined the company's exploration staff in Ventura, California, in 1942. He was appointed assistant paleontologist there in 1943, and in succeeding years served as district and divisional geologist.

In 1955 he became western division exploration manager, with headquarters in San Francisco where he will continue to be located in his new assignment.

H. H. Neel

R. E. McPhail

R. E. McPhail has been promoted to southeast regional manager in Phillips Petroleum Company's land and geological department. McPhail, with headquarters in Bartlesville, Oklahoma, replaces **J. E. Kendall,** resigned. He was formerly assistant manager and regional geologist of the southeast region. **R. I. Sewell,** regional landman, has been advanced to assistant regional manager, and **H. R. Segnar** has been promoted to southeast regional geologist from his former position of division exploration geologist at Oklahoma City. **E. F. Wroblewski,** who has been district exploration geologist at Ardmore, Oklahoma, succeeds Segnar and **M. A. Vaughn,** previously assistant division exploration geologist at Oklahoma City, replaces Wroblewski at Ardmore.

G. D. Robertson, manager of Shell Oil Company's Houston production division and a veteran Gulf Coast geologist, has retired. Robertson was honored at a Shamrock-Hilton Hotel luncheon attended by close associates, who presented him with a motion picture camera and accessories. He retires after more than 23 years with the Shell organization.

H. J. Ward, general field superintendent of the Delta Drilling Company, has been transferred to Benghazi, Libya, to be in charge of drilling operations there. **C. W. Gold** has been promoted to be division drilling superintendent at Casper, Wyoming.

Herman H. Kraveler, petroleum engineer and management consultant of Tulsa, has been employed as consultant for Saskatchewan's oil and gas conservation board. He will be adviser to the board and mineral resources department on all matters pertaining to oil production, operation and regulation.

Lester T. Potter has been elected president to succeed **D. A. Hulcy,** Lone Star Gas Company. Hulcy has been president for 17 years and chairman of the board since 1952. He will remain chairman at the request of the directors. Potter was formerly vice executive president.

Hugh T. Richardson has been appointed chief geologist for Standard Oil Company of Texas. Richardson assumes the post formerly held by G. L. Whipple, now deceased.

C. W. Hamilton, vice president, Gulf Oil Corporation, and chairman of the board, Gulf Eastern Company, London, England, has retired.

W. A. Shellshear has been named Houston district manager, **W. W. Ramseur** the new manager in Jackson, Mississippi, **R. A. Payne** the new manager in New Orleans, Louisiana, and **B. W. Haywood** the new manager in Shreveport, Louisiana for Gulf Oil Corporation. **J. P. Weichert,** zone superintendent of production at Pierce Junction, is appointed district production manager, Houston district; **M. C. Coleman,** assistant zone superintendent of production at Laurel, Mississippi, to district production manager, Jackson district; **W. B. Hopkins,** zone superintendent of production of the Shreveport zone, is named district production manager, New Orleans district; **F. J. Mikeska,** assistant zone superintendent of production of the Shreveport zone, to district production manager, Shreveport district; **T. R. Deen,** now zone exploration manager, Houston zone, to district exploration manager, Houston district; **J. L. Herndon,** zone exploration manager, Shreveport zone, to district exploration manager, Jackson district; **H. D. Ritter,** zone exploration manager, New Orleans zone, to district exploration manager, New Orleans district, **R. C. Howard,** zone geologist, Houston zone, to district exploration manager, Shreveport district.

Warren Pond has joined Trunkline Gas Company as Houston district landman. His headquarters will be in the company's district office in Houston, Texas. Prior to joining Trunkline Gas, Pond worked five years for Gulf Oil Corporation in Houston and later in Midland. He has also worked as an independent oilman.

Claude D. Freeman has retired after 35 years as office manager of Sun Oil Company's southwest division. **Noland E. Anderson,** assistant office manager succeeds Freeman. **Wilbur C. Keith,** formerly supervisor of general accounting, will become assistant office manager.

Roland C. Smith, geologist, has joined the staff of Wm. Ross Cabeen & Associates located in its new offices in Dallas, Texas. Before joining Cabeen, Smith was assistant to the regional exploration manager, Dallas eastern region of the Atlantic Refining Company. **Joseph C. Roberts** has also joined the Cabeen group in its Lima, Peru offices. Roberts was formerly district geologist with Shell Oil Company in Corpus Christi, Texas.

Arthur R. Erickson has been named exploration manager for Northern Natural Gas Producing Company, a wholly owned subsidiary of Northern Natural Gas Company of Omaha, Nebraska. He was formerly chief geologist.

A. R. Erickson

G. L. Buckles

George Buckles announces the formation of the consulting firm of George L. Buckles Company with offices in Monahans, Texas. The new company will specialize in waterflooding. He has been associated with the consulting firm of Buckles and Hostetler since 1951.

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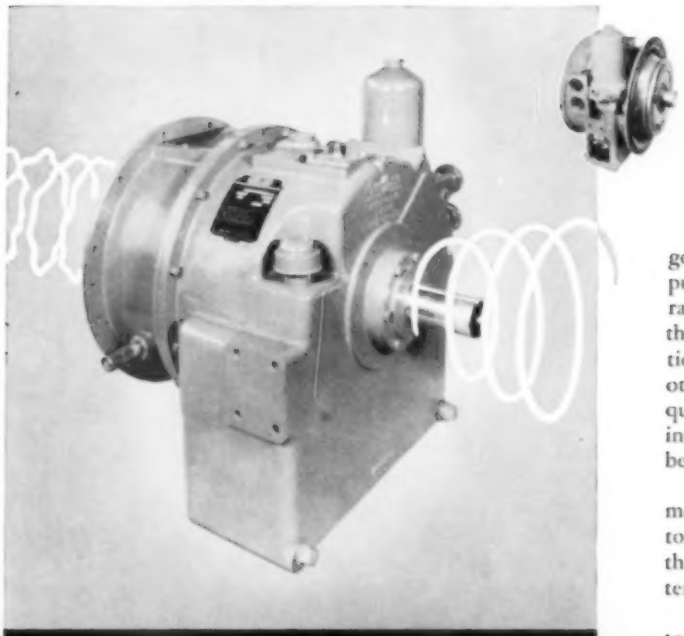
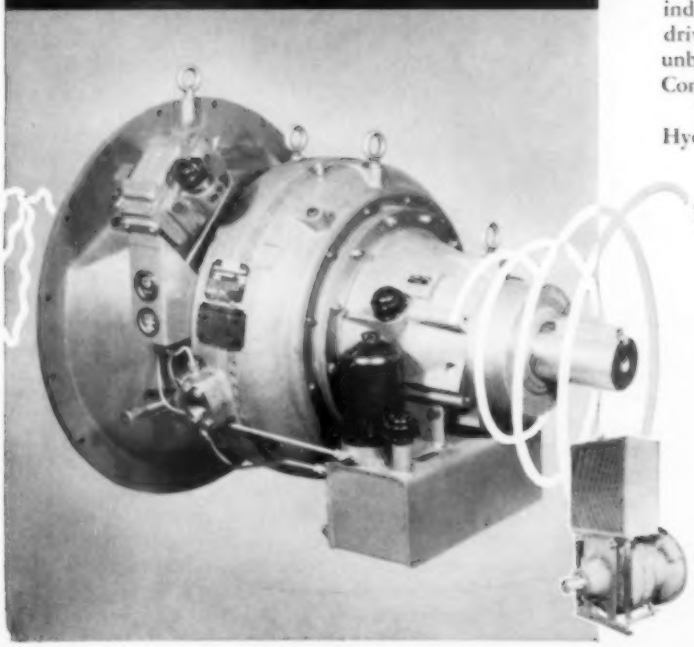


Single-Stage Torque Converters or Three-Stage Torque Converters?



The answer to the question of "single-stage vs. three-stage" depends largely on the characteristics of the equipment you manufacture or use and the jobs it is required to do. Naturally, many factors must be known before any engineering department can be expected to make recommendations.

Generally speaking, however, when it is desired to have minimum pulldown from governed engine speed—with maximum power output over a wide range—and to produce high torque ratios for hoisting or heavily loaded vehicles, a three-stage torque converter, with torque multiplication up to six times, may be most desirable. On the other hand, where mild torque conversion is required, as in certain types of vehicles and in other industrial equipment—a single-stage converter may be the best choice.

Now you can benefit from the unbiased recommendations of one manufacturer in choosing a torque converter—single-stage or three-stage—with the exact capacity and torque transmission characteristics to give your equipment maximum efficiency.

Twin Disc Clutch Company's line of single-stage torque converters—available as the 1300 and 1500 Series units—complements its time-tested, universally accepted line of five series of three-stage units. Single-stage *or* three-stage—from 30 to 1000 hp—you can depend on Twin Disc Torque Converters to give your equipment better performance . . . less downtime . . . and greater earning potential.

In addition to offering the most complete, the most versatile line of industrial torque converters available, Twin Disc manufactures fluid couplings in a wide range of sizes for engines and motors from ¾ to 850 hp, and friction clutches for applications from fractional to 1050 hp.

For smooth, dependable transmission of power to your equipment and machinery, standardize on Twin Disc—the world's leading manufacturer of industrial fluid and friction drives. Whatever your drive problem, you can count on Twin Disc for unbiased recommendations . . . for Twin Disc Clutch Company makes them all.

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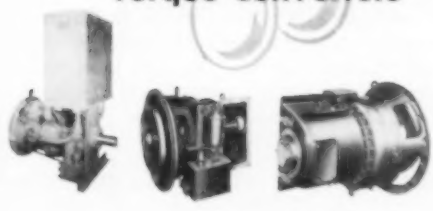

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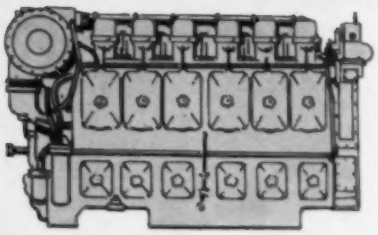

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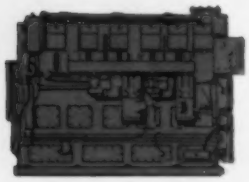
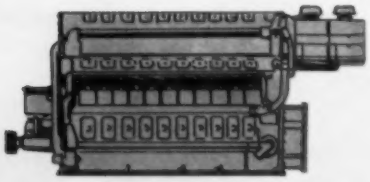


CLIMAX



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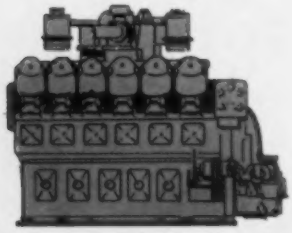

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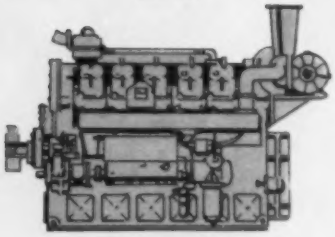

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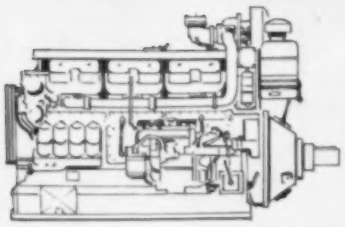

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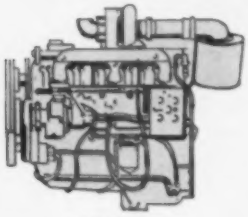

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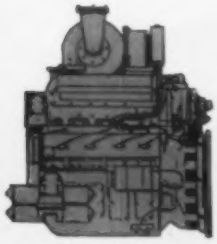

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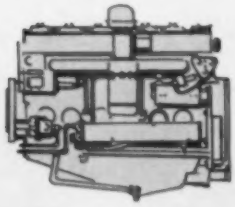

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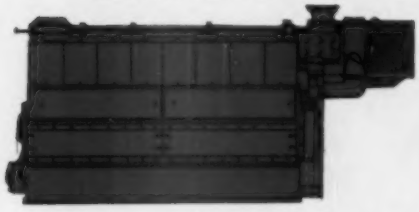

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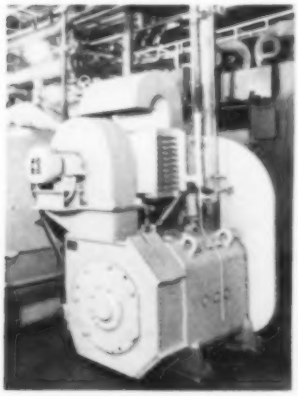

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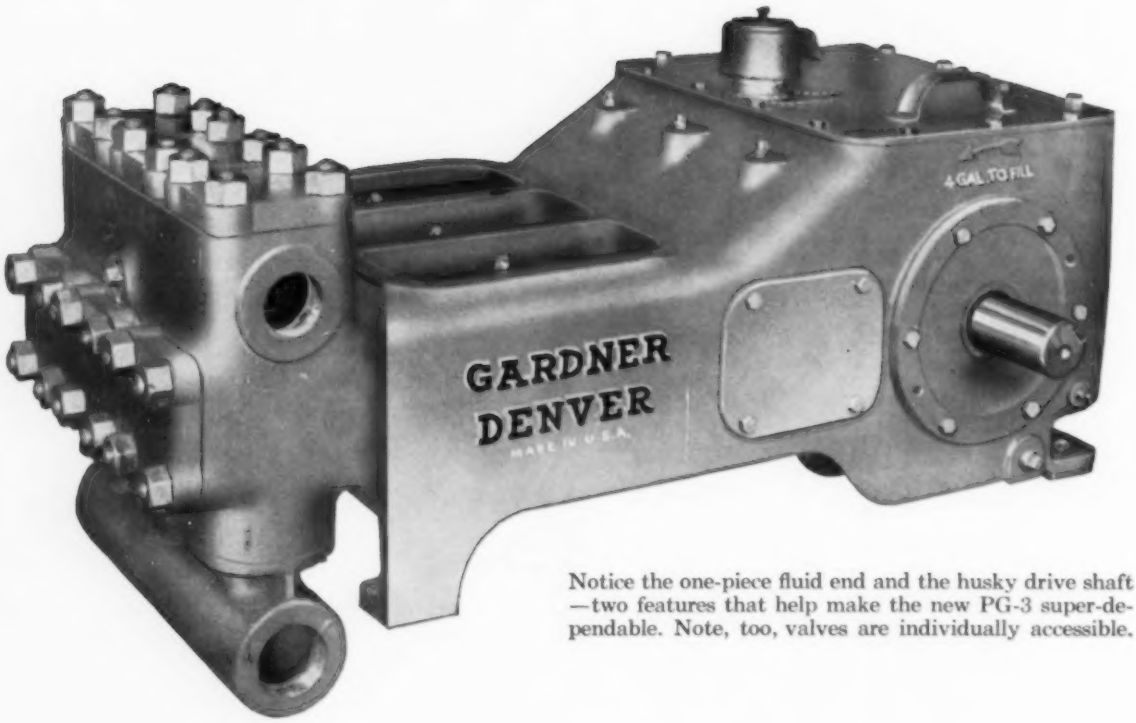

Notice the one-piece fluid end and the husky drive shaft —two features that help make the new PG-3 super-dependable. Note, too, valves are individually accessible.

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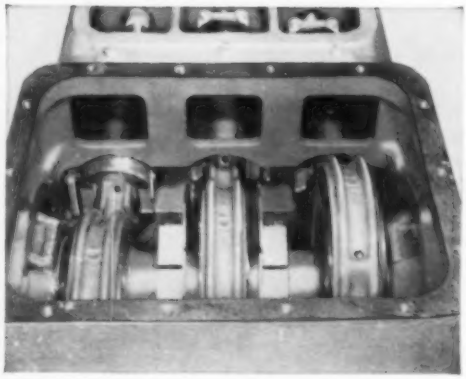
. . . new Gardner-Denver waterflood pump

In this new triplex plunger pump you get famous Gardner-Denver reliability that keeps costs down. With this addition to the line, you can choose with more exactness than ever the Gardner-Denver pump for salt water disposal and waterflood service that meets any set of field conditions.

GARDNER-DENVER WATERFLOOD PUMPS—CONDENSED SPECIFICATIONS

Model	PL-7 6-cyl.	PA-8 Triplex	PE-5 Triplex	FG-FXG Duplex	FF-FXF Duplex	PG-3 Triplex	LE-LXE Duplex
Type	plunger	plunger	plunger	piston	piston	plunger	piston
Input hp —up to	240	160	75	60	40	30	24
Discharge psi —up to	3,360	1,455	2,700	895	640	3,050	820
Bbl. per day —up to	13,200	9,000	7,300	6,000	4,500	1,600	3,000

For higher pressures, consult your Gardner-Denver representative. Complete specifications on the new PG-3 and on any or all of the six other pumps will be sent to you promptly on request.



Here's the eccentric drive. It permits use of the straight shaft of large diameter. The new PG-3 also has one-piece connecting rods—a third contribution to dependability under any operating conditions.

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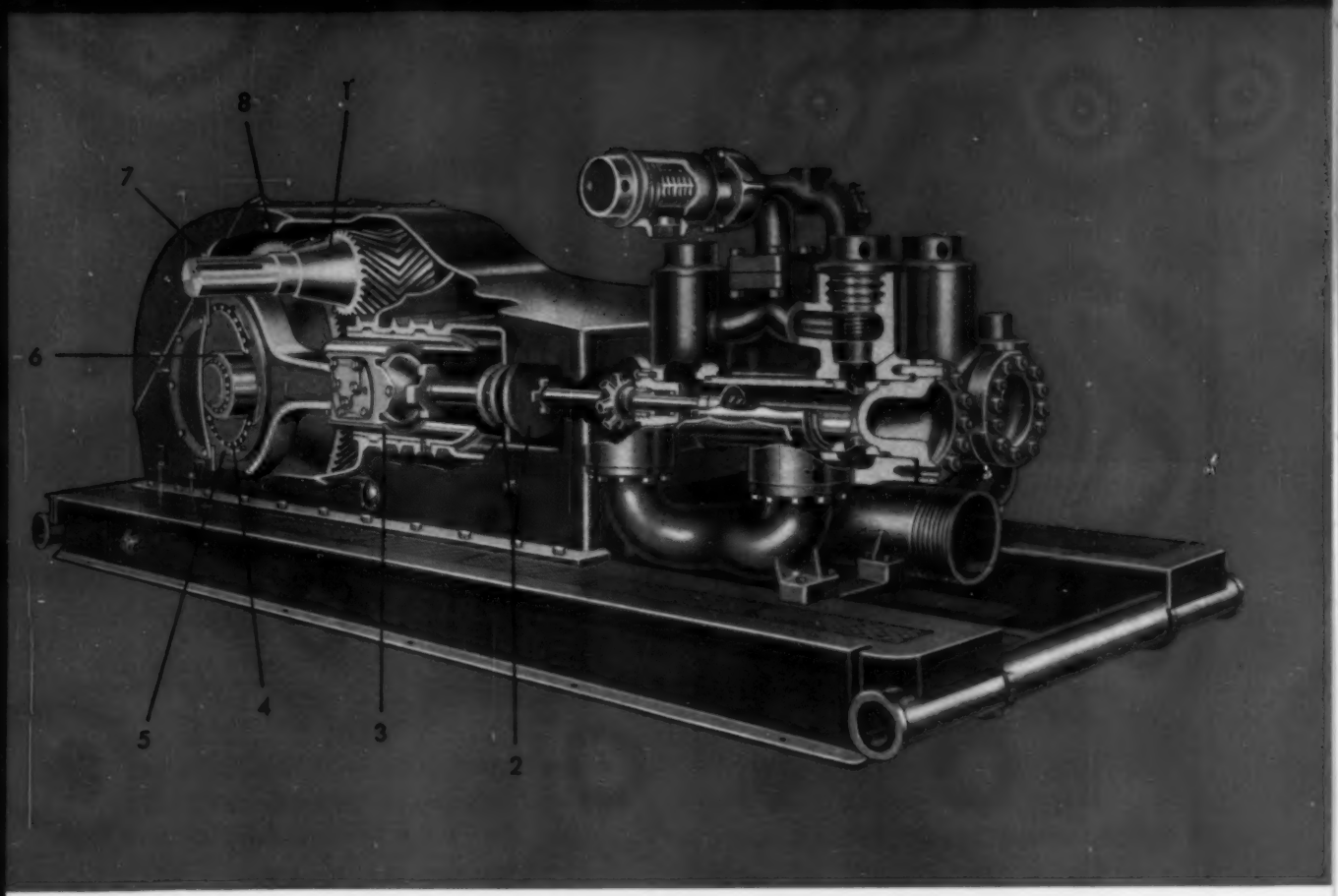

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..depends upon Power-End design

By the cross sectional drawing, you can see why Tool Pushers and Drillers place so much reliance in the power ends of Continental-Emsco slush pumps. In addition to their rugged construction, these power ends are surprisingly lightweight due to their *Fabriform* construction. In this new concept of pump design, the conventional heavy, bulky casting has been replaced by steel plates, formed and fabricated into a compact, rigid frame. You get *more horsepower per pound* than in any other slush pump.

POWER END FEATURES

1. One-Piece, Forged-Steel Pinion and Shaft
2. Packing Gland and Rubber Baffle Keeps Mud From Power End
3. Replaceable Crosshead Slippers and Frame Guides
4. One-Piece Eccentric Straps, Equipped With Large-Diameter, High Capacity, Retainer-Type Roller Bearings
5. Combination Splash-and-Pressure Lubrication System
6. Roller Bearings Used Throughout
7. All-Steel, Fabriform Constructed Power End
8. Demountable, Forged-Steel Herringbone Gear

"D" Series Slush Pumps give you all these wanted, needed fluid end features

- ★ Precharged Pulsation Dampener
- ★ 360° Swiveling Screen, Protects Discharge
- ★ Heavy, Coarse-Pitch Threaded Valve-Pot Covers
- ★ Cylinder Head Lock Liner
- Shear Relief Valve
- Liners Packed at Both Ends, Exposed to View
- Screw-Type Stuffing Boxes
- Two-Piece Fluid End on DA-850 and D-1000
- Four-Runner Skid, Standard on D-700, DA-850, D-1000

★ All models except D-175 and D-300

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Serving the Oil and Gas Industries ... Worldwide

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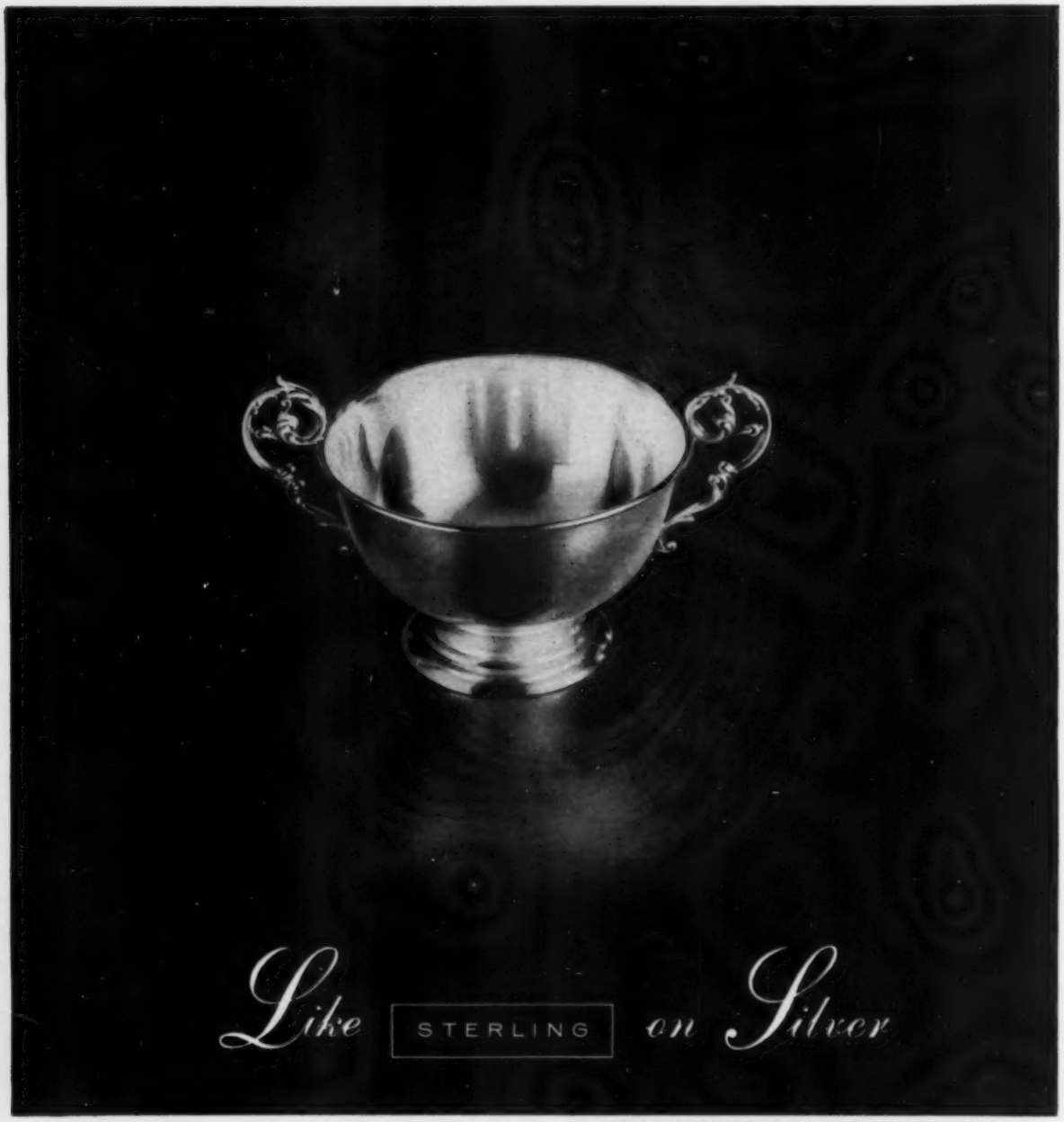

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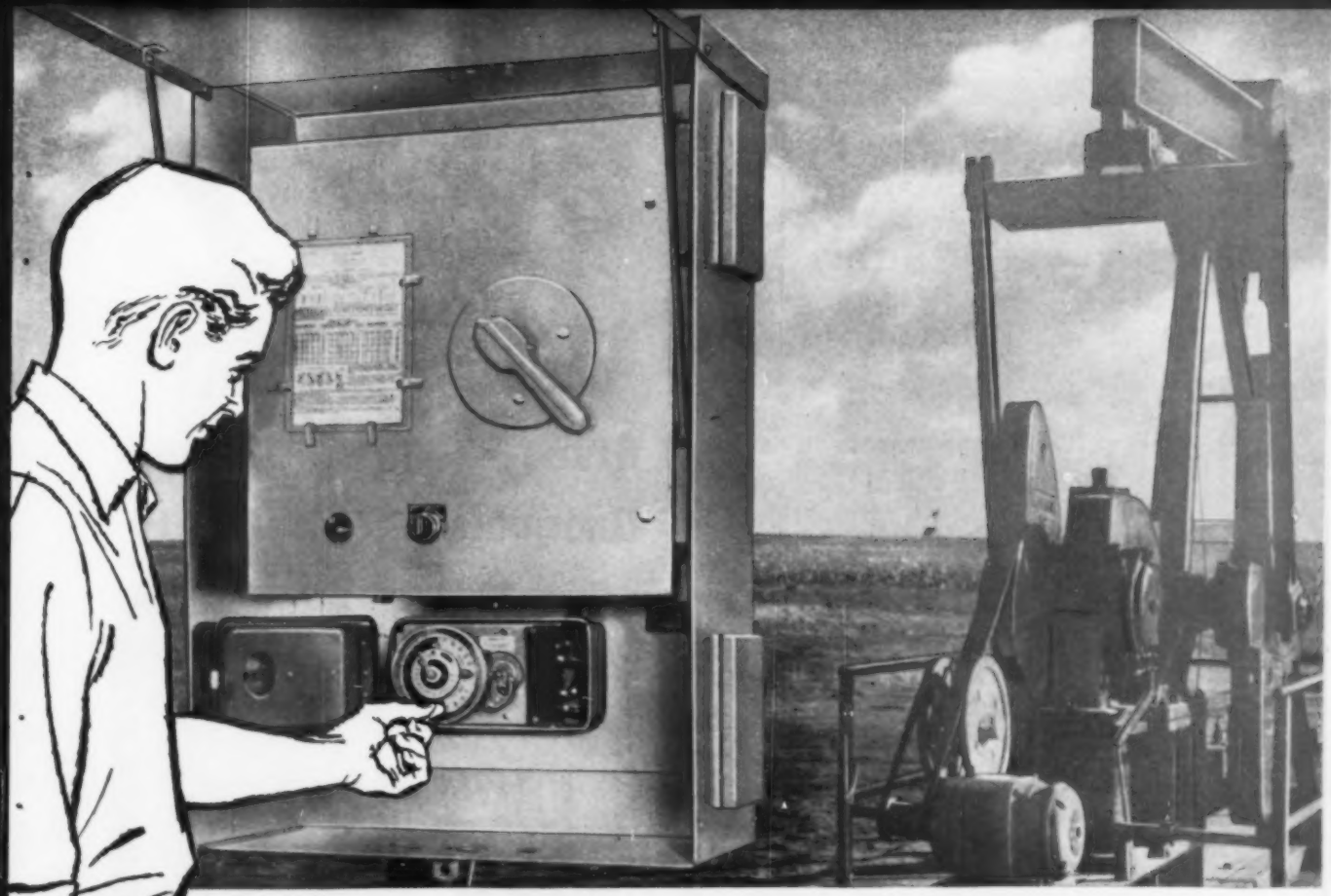
the Petroleum Engineer



"Practically thinks for itself"

The new Cutler-Hammer Three-Star Oil Well Pumping Control has performed so successfully and proven so completely dependable that the leading oil field men everywhere insist on C-H control for all their pumping wells and accept no substitutes. Ask these men why and they will tell you, "That new C-H three-star control beats them all. No matter how tough it gets, our pumps keep pumping; and that Supertimer practically thinks for itself." Your first pumping well equipped with Cutler-Hammer control will prove to you what these men know . . . Cutler-Hammer Three-Star Oil Well Pumping Control will out-perform, out-protect, out-last and serve better than all others.

This control has *everything*, particularly the engineered dependability so vital in any automation . . . nothing is left to chance. Insist on the finest, insist on Cutler-Hammer . . . leading manufacturer of *automation* control.

Your nearby Authorized Cutler-Hammer Distributor is stocked and ready to serve you. Order from him today. CUTLER-HAMMER, Inc., 1459 St. Paul Avenue, Milwaukee 1, Wis. *Associate:* Canadian Cutler-Hammer, Ltd., Toronto, Ontario.

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MOTOR CONTROL
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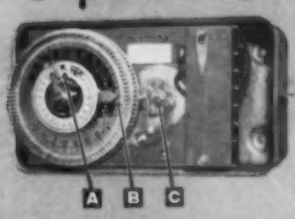
Member American Petroleum Institute

New CUTLER-HAMMER Supertimer



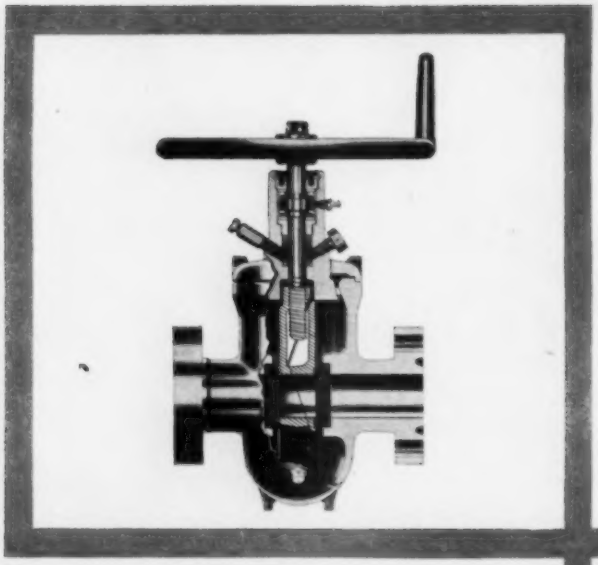
This is *automation* in action. You pre-set the Supertimer to meet your field allowable and the control will do the rest, automatically. It starts, stops, restarts and cycles indefinitely, precisely according to your schedule. If a power outage occurs, any number of C-H controlled pumps can be restarted in an exact sequence to avoid overloading the power lines on inrush. Unfortunate coincidental starting of even two pumps is impossible.

- **A** Sets the precise restarting time delay from zero to 180 seconds. This is exclusive with the Supertimer—random starts or coincidental starts of even two pumps are impossible.
- **B** Sets the daily pumping schedule—pull a tab for each fifteen minutes of pumping, space them through the daily 24 hour period as desired.
- **C** Sets the weekly pumping schedule—1, 2, 3, 4, 5, 6 or 7 days per week as desired.

COMPLETE PROTECTION
The control is protected against lightning with exclusive, advanced-designed lightning arresters; and the three coil overload relay protects the pump motor from overloading and dangerous single phasing which often results from lightning.

CHIMNEY DRAFT VENTILATION
The heat-reflecting, aluminized enclosure insures a constant circulation of air . . . no nuisance tripping because of trapped heat.

DUST SAFE CONTACTS
Dust-Safe vertical contacts stay clean and eliminate the necessity of contact replacement common to other designs.



new!

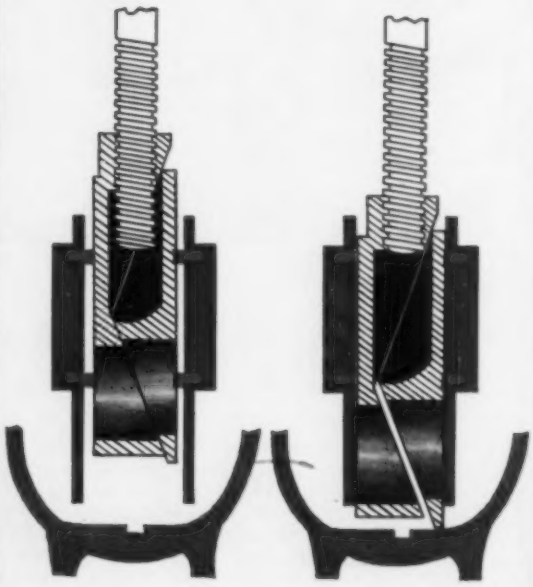
EXCLUSIVE DOUBLE-TIGHT SEAL**

Gives W-K-M Valves Unequaled Sealing Ability

W-K-M's Exclusive DOUBLE-TIGHT SEAL literally doubles the sealing efficiency of W-K-M* Valves. A specially designed Teflon† seat insert is the secret of the DOUBLE-TIGHT SEAL. The first seal occurs when the expanding gate and segment faces contact the Teflon insert. The second seal is made by intimate contact of gate and segment faces and metal seat. Together, the Teflon and metal seal ring provide the DOUBLE-TIGHT SEAL which holds the heaviest viscous fluids—the lightest gases at pressures up to 5000 psi. The DOUBLE-TIGHT SEAL is applied both upstream and downstream.

The self-lubricating Teflon insert provides a smooth, slick surface for the gate and segment to glide across. It compresses when the gate and segment expand in the open or closed position. The Teflon insert will not flow—it is immune to acids, alkalis and all petroleum fractions. It will not vulcanize—and never requires lubrication.

DOUBLE-TIGHT SEAL is another in the long list of advantages which mean better performance, longer service, lower upkeep with W-K-M through-conduit gate valves. Teflon inserts are standard on all oil field valves through 4" up to 5000 psi w.p. and are available for larger size valves. Seats with Teflon inserts can be put in W-K-M Valves now in service.



INTERMEDIATE POSITION: Exaggerated view showing gate collapsed during opening and closing. Notice the Teflon seal retains contact with gate and segment. Foreign matter cannot fall into valve body.

CLOSED POSITION: Metal-to-metal forced seal with Teflon compressed into seat by parallel expansion of gate and segment. The Teflon wipes the metal surfaces clean for perfect seal.

**PAT. PEND. †DU PONT'S TETRAFLUOROETHYLENE RESIN. © 1957, acf INDUSTRIES, INCORPORATED. *TRADEMARK OF acf INDUSTRIES, INCORPORATED.

W-K-M

DIVISION OF acf INDUSTRIES INCORPORATED

PLANT: MISSOURI CITY, TEXAS
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Write Dept. F-8 for your copy of W-K-M Catalog 200 which covers the complete line of W-K-M Through-Conduit Gate Valves for Oil Field Services.

MANUFACTURERS OF W-K-M GATE VALVES acf LUBRICATED PLUG VALVES KEY-KAST ALLOY STEEL PIPING FITTINGS KEY RETURN BENDS AND FITTINGS

8717

There is a difference in sucker rods

For over 65 years, the S. M. Jones Company has applied **advanced** *field research, engineering, and metallurgy to the manufacture of sucker rods.*

RESULTS: **Jones Sucker Rods** that are the standard of comparison because of their *proved* **longer life.**

"The S. M. Jones Company modern manufacturing plant, Toledo, Ohio"

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Be sure to specify Orbit's 6,000-10,000 lbs. Test Valves for your next Christmas trees to handle high pressure production. They're specially designed for maximum trouble-free and easy operation, and are now available at your favorite Well Head Manufacturer.

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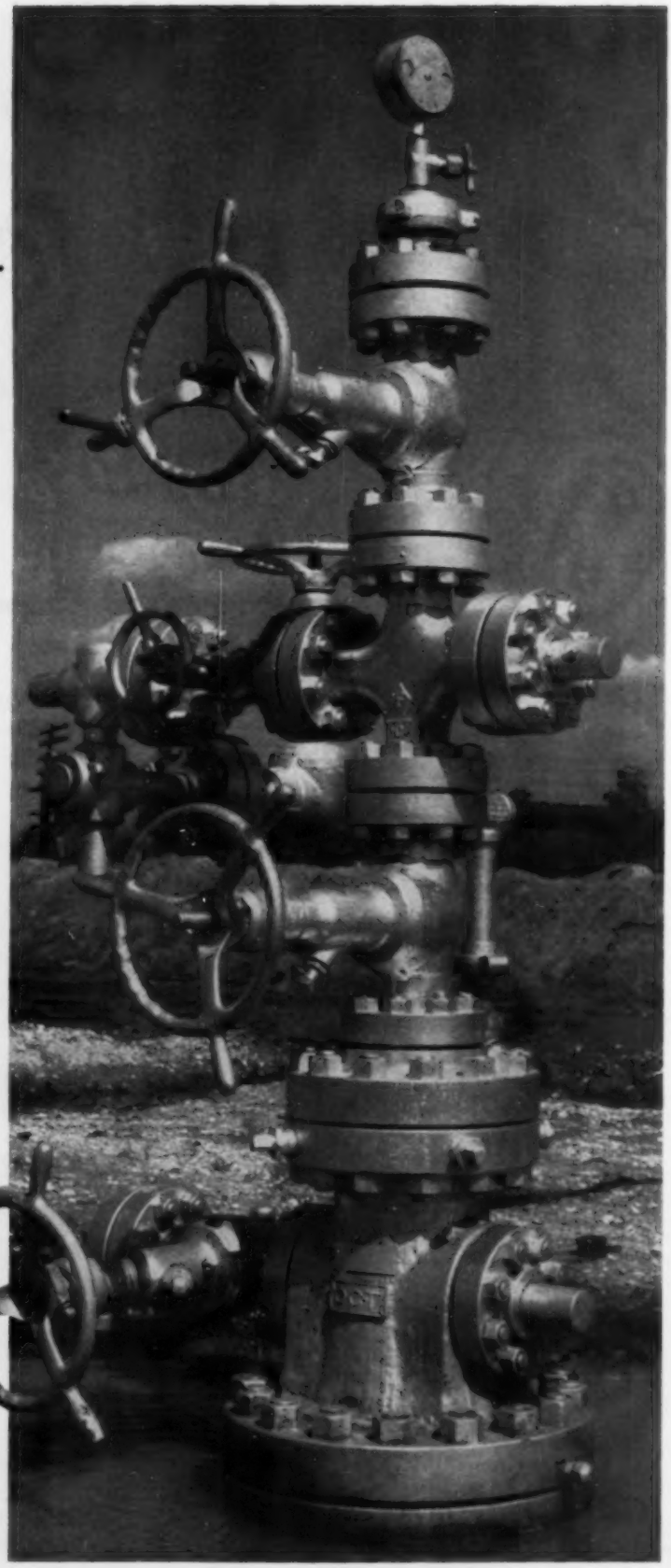


With Magcobar

logging can begin on time, on schedule to save you money

A well-planned and executed mud program can save money all along the line. For example, when the mud is properly conditioned for logging, with the proper weight, the right viscosity, correct gel strength, etc., logging proceeds on schedule without costly delay. Your well is ready for logging as soon as the desired depth is reached. When desired, mud resistivity can be controlled to improve log interpretation. To help you in both the planning and the execution of your mud program, the Magcobar team will work right along with you.

Magcobar's complete drilling mud service brings you the right drilling mud chemicals for each foot of hole. Magcobar's mud engineers are the best trained and best qualified in the mud industry. The full facilities of Magcobar can help you to lower the over-all cost per foot of hole drilled. Plan now to make full use of Magcobar's *complete* drilling mud service on your next well.

Magnet Cove Barium Corporation
Houston, Texas

Magcobar®
Complete
DRILLING MUD SERVICE

87-101

NEW!

The Dorr-Oliver CLAYJECTOR for Controlling Weighted Muds

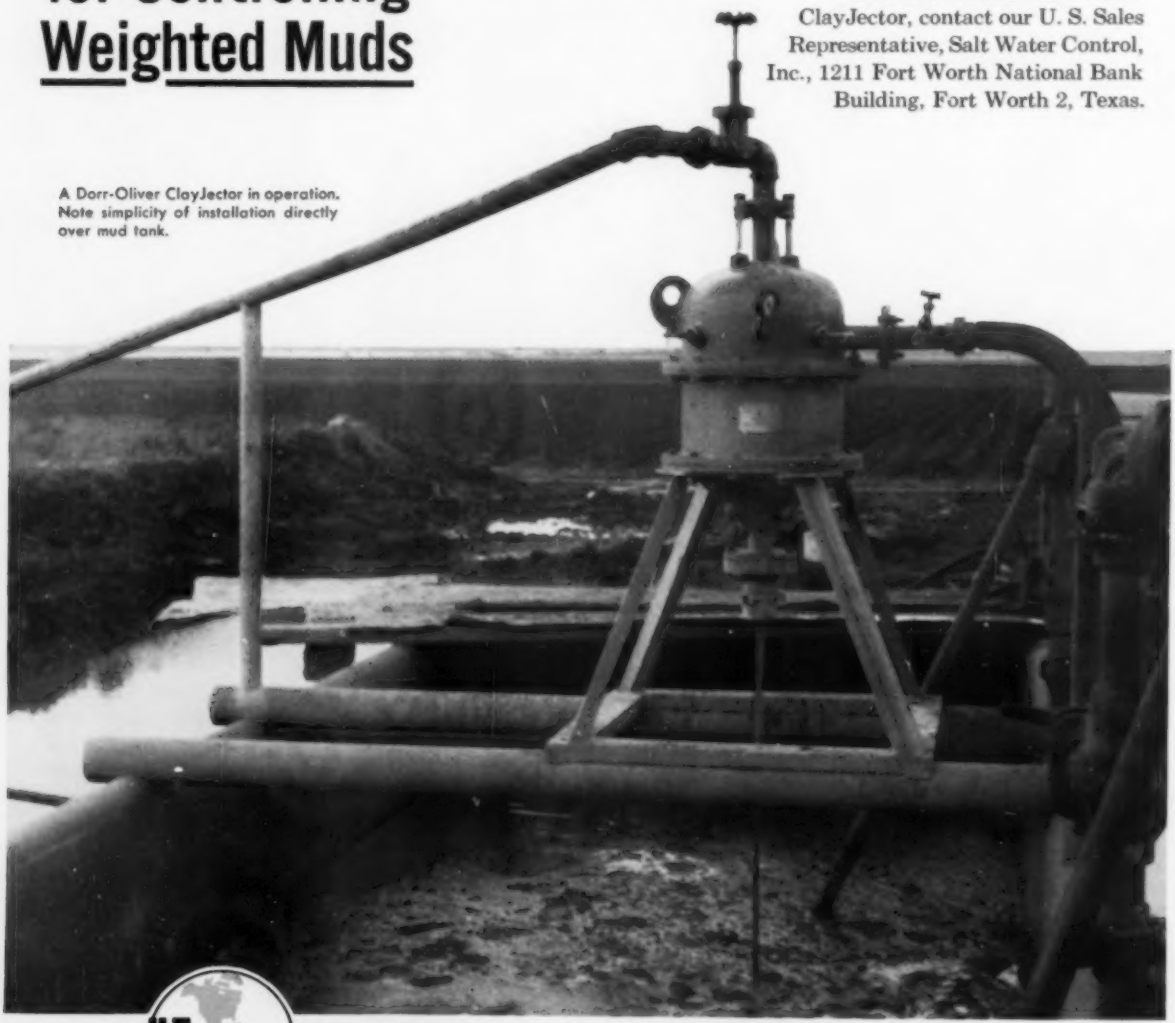
Latest development in controlling drill mud weights is the Dorr-Oliver ClayJector. This new unit is designed specifically for weighted muds . . . will mechanically reject undesirable drilled solids and retain the valuable barites (weighting materials) in the system. Optimum solids content is maintained at a minimum cost for barites which would be lost if solids are controlled by dilution and jetting tanks.

On one recent rig installation where a ClayJector was installed to maintain a 17 lbs./gal. mud system, the conservative estimate of savings was $425 per day!

Key to ClayJector efficiency is the DorrClone classifier, a cylinder-conical unit using centrifugal force in place of gravity. Four of these units are manifolded in a common housing with a common feed, overflow, and underflow. Any of the units can be cut out of service without opening the housing to meet variations in circulation requirements.

For more information on the ClayJector, contact our U. S. Sales Representative, Salt Water Control, Inc., 1211 Fort Worth National Bank Building, Fort Worth 2, Texas.

A Dorr-Oliver ClayJector in operation. Note simplicity of installation directly over mud tank.



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WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
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Locations in the United States and Canada

McCullough® REPORTS TO THE OIL INDUSTRY

Service
Anywhere Anytime

New Services • • • New Tools • • • New Methods • • • Outstanding Results

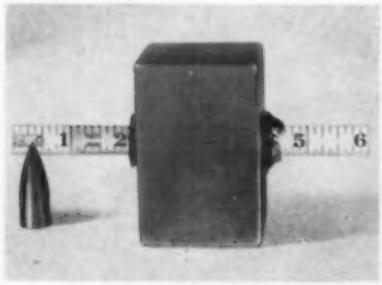

Illustration above shows a 2½" steel test sample pierced by an improved ½" Ogival Bullet fired by a McCullough M-3 Bullet Perforator.

McCullough Sectional Gun Gains Penetration Where Previous Attempt Failed

Depth of operation was only 1487'. 4½" O.D. casing had been cemented in 10¾" hole. Pay zone was bullet perforated by another service company but the formation would not break down. During the attempt to fracture, the pipe split above the zone and collapsed in the perforations.

Operator swaged out the 4½" casing, ran a 3" liner inside the 4½" and cemented the annulus. This operation made an impressive amount of steel and cement to be penetrated to gain production.

McCullough shot 20 improved ⅜" Ogival Bullets in the zone and the formation broke down at 800 lbs. Time on the job was one hour. Results: a good well and a satisfied oil man.

McCullough Sectional Guns are available in 1⅛" O.D., 1¾" O.D. and 2¼" O.D. sizes.

Powerful M-3 Guns Increase Production 316%

Hard Shooting M-3 Guns, Firing Improved Ogival Bullets, Gain 38 B/D Over Previous Jet Perforating

An excellent example of the penetrating power of McCullough M-3 Bullet Guns was recently reported from a California oilfield.

This was a shallow, low production field. The well had previously been perforated by another service company with shaped charges for a settled production of 12 barrels of oil per day.

Productive interval lay between 3837' and 3872' and was cased with special 7" O.D. 51 lb. casing. Casing was cemented in 9¾" hole through the pay zone.

Although skeptical of the ability of any bullet perforator to gain effective penetration through the extra heavy casing and thick cement sheath, the operator called for McCullough M-3 Bullet Guns.

McCullough Service Crew made three runs with 4¾" O.D., 20-shot M-3 Guns, firing 140 improved ½" Ogival Bullets, four per foot, in the 35' zone.

Production increased from 12 to a settled 50 barrels of oil per day—a gain of 38 barrels. The job required two hours, including rigging up and tearing down. To quote the operator, "Results were very satisfactory and gratifying".

"world's hardest shooting bullet perforator"

M-3 Penetrates Two Strings For a Good Well

Two strings of casing had been set through the pay zone at 5587'–5590'. 5" O.D. 18 lb. liner was cemented in 7⅝" O.D. 28 lb. casing which, in turn, was cemented in 11¼" open hole.

A 3½" O.D. McCullough M-3 Gun fired 18 improved ½" Ogival Bullets in the three foot pay zone. Operator stated he is satisfied it is his best completion to date.

Burr-Free Penetration

A new Burrless Bullet Cap, if desired, is inserted over the point of the improved Ogival Bullet at the time the M-3 Gun is loaded. It provides a completely burr-free hole on the inside surface of the perforated casing. Symmetrical, smooth holes make the use of ball sealers more effective in acidizing and sand fracturing—assuring more complete perforation shut-off

Burr-free holes make casing scraping only a routine, precautionary measure and insure free passage of swabs, packers or other close fitting tools.

The jobs described above are certified to be true and accurate field reports of services rendered.

McCullough® TOOL COMPANY

Cable Address: MACTOOL

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HOUSTON
EDMONTON

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Evidence

Through a program of research and development, Camco is able to bring to the oil industry new and more efficiently designed equipment and improved services. In 1955, Camco introduced the first wireline truck with hydraulic power and electronic control. In 1957, Camco takes great pride in presenting the latest in wireline truck design—the Camco Model No. 3. For wireline services, call your nearest Camco representative, or write Box 14484, Houston 21, Texas, for complete information.

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# of Progress

IN THE INDUSTRY

CAMCO MODEL 3
Wireline Truck

overwhelmed...

With the performance of his

oilmaster

HIGH-VOLUME PRODUCER PUMP

In a water flooding operation, or in the later life of a water drive field, the problem of pumping large quantities of water is a very real one. Some operators change to a larger size tubing at a considerable increase in capital expenditure. Others produce all they can with a tubing-type pump running at the maximum possible stroke and motion. A third alternative is the new Oilmaster High-Volume Producer Pump.

The Oilmaster High-Volume Producer Pump, as the name implies, is specifically designed to handle large quantities of fluid. It is actually two pumps operating in tandem, capable of displacing far more fluid than is possible with a single pump. The upper pump is barrel travel, providing the strength and rigidity so desirable in the traveling assembly of a pump, while the lower pump is plunger travel, with the excellent pump suction characteristics needed for producing large volumes of fluid. The High-Volume Producer Pump discharges fluid both at the top and bottom of the pump, displacing the fluid with a minimum of pressure drop and keeping the annulus between the pump and the tubing flushed free of sand.

If lifting large volumes of fluid is one of your requirements, ask your Oilmaster Representative about the High-Volume Producer Pump, and prepare to be OVERWHELMED when you find how much fluid can be produced with an Insert Rod-Type Pump from a given size tubing.

oilmaster PUMPS FOREMOST IN THE INDUSTRY

FLUID PACKED PUMP CO.

Main Office and Plant, Los Nietos, California

Distributed by the National Supply Co., Pittsburgh, Pa.
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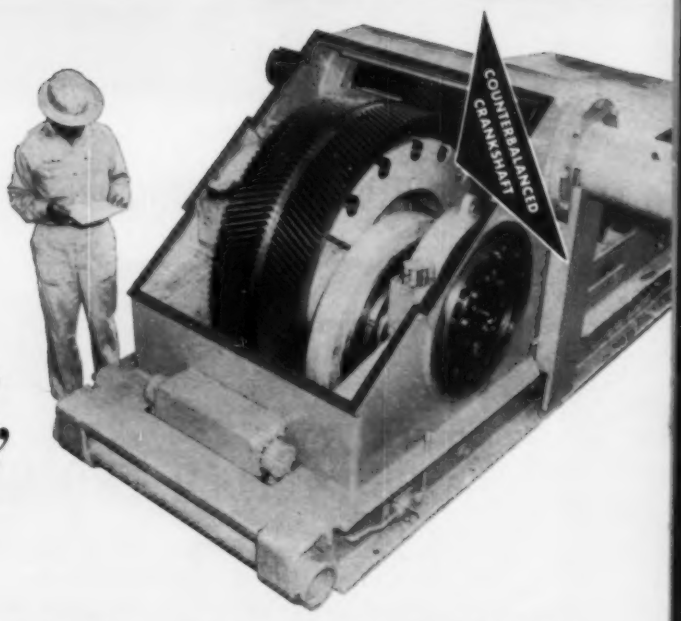
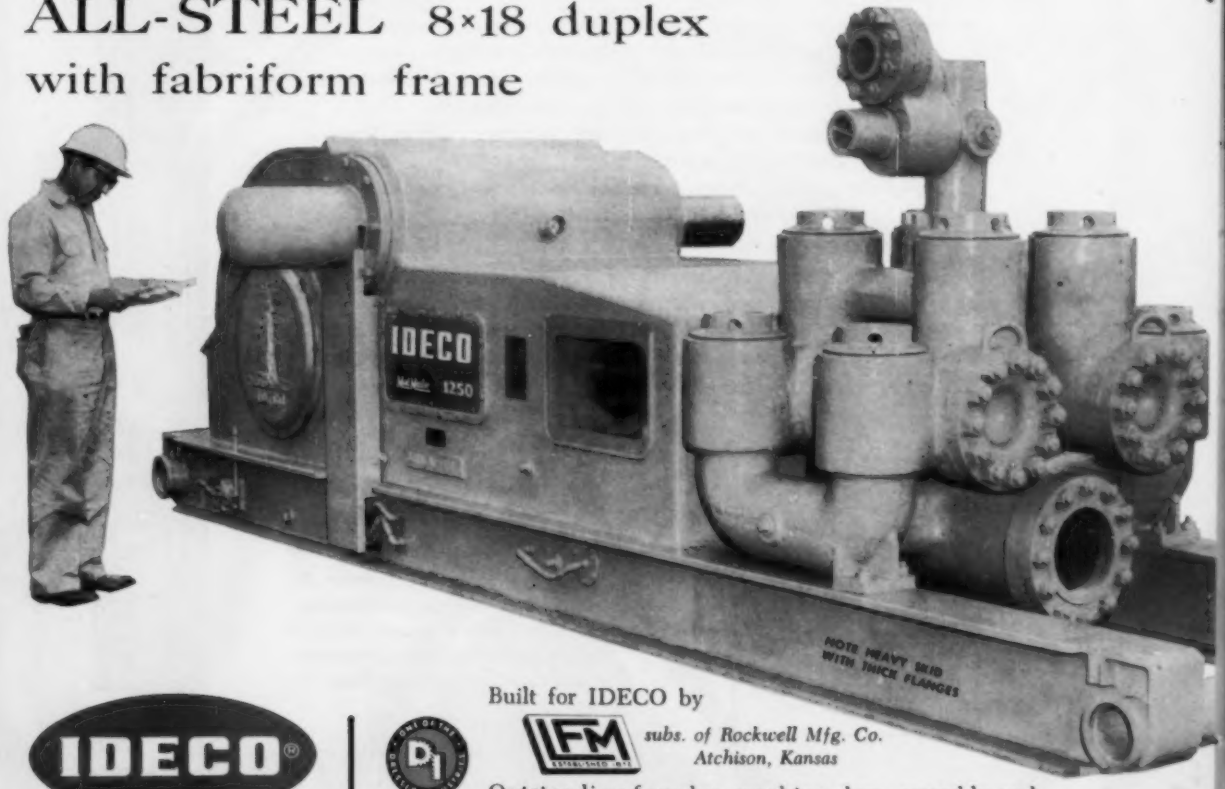
Schematic drawing of Oilmaster High-Volume Pump shown on upstroke. Note how the full lower pumping chamber fills directly from the standing valve while the upper annular chamber fills through the hollow polished rod. On the downstroke, fluid is discharged both from the valve in the top cage and from the bottom discharge valve above the hold-down.

Here it is... the pump for deepest drilling, heaviest duty



1250 h.p. MUD-MASTER

ALL-STEEL 8×18 duplex
with fabriform frame



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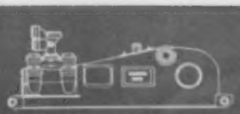
Built for IDECO by

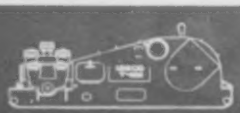
LFM *subs. of Rockwell Mfg. Co. Atchison, Kansas*

Outstanding foundry, machine shop, assembly and testing facilities for the manufacture of mud pumps.

Now MUD-MASTER DUPLEX 1250



MUD-MASTER DUPLEX 600



Now FLO-MASTER TRIPLEX T-880

Now FLO-MASTER TRIPLEX T-440

Completely strain-gauge tested

... PROVING RESERVE STRENGTH OF ALL-STEEL CONSTRUCTION

1250 h.p. is an ACTUAL RATING for this big Mud-Master — NOT A RE-RATING. Both dynamic and static strain gauge tests conclusively proved its design.

Fluid end tested to 9,000 p.s.i.

... 9,000 P.S.I. DISCHARGE SIDE; 4,500 P.S.I. SUCTION

One-piece cast steel fluid end has thick, high-strength walls around sweeping passages which eliminate eddies, give high volumetric efficiency.

2-piece threaded valve pot covers

... FEMALE THREADS ARE INTEGRAL WITH CASTING

Greater valve cover strength and quick removability is assured with Ideco's new 2-piece design. Union effect allows plug to compress packing without rotating.

Lowest weight per horsepower

... ONLY 43.8 LBS. PER H.P.; 54,788 LBS. TOTAL

All-steel construction with fabriform frame and integral skid permits a strong, compact design with lowest weight per horsepower. Saves space and transportation cost.

Counterbalanced crankshaft

... SMOOTHS OUT PUMP OPERATION

Entire crankshaft assembly is precision counterbalanced for lower impact loading, smoother pump operation—a feature particularly important on barge and offshore installations.

Pressure lubricated throughout

... TWIN POWER END PUMPS MOUNTED OUTSIDE FRAME

Two separate pumps driven from the main gear deliver positive flush-out lubrication inside bearing races. Rods lubricated through inside of stuffing box glands.

Falk-cut herringbone gears

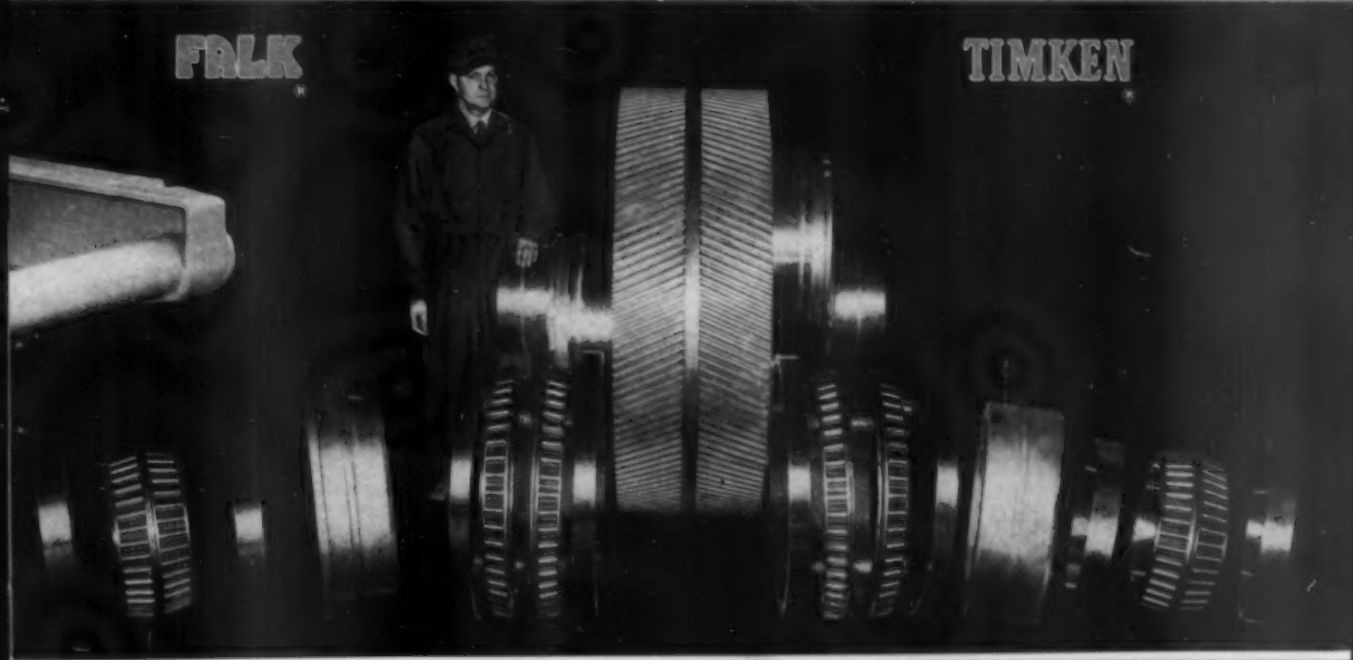
... 20-IN. WIDE; REVERSIBLE FOR EXTRA LIFE

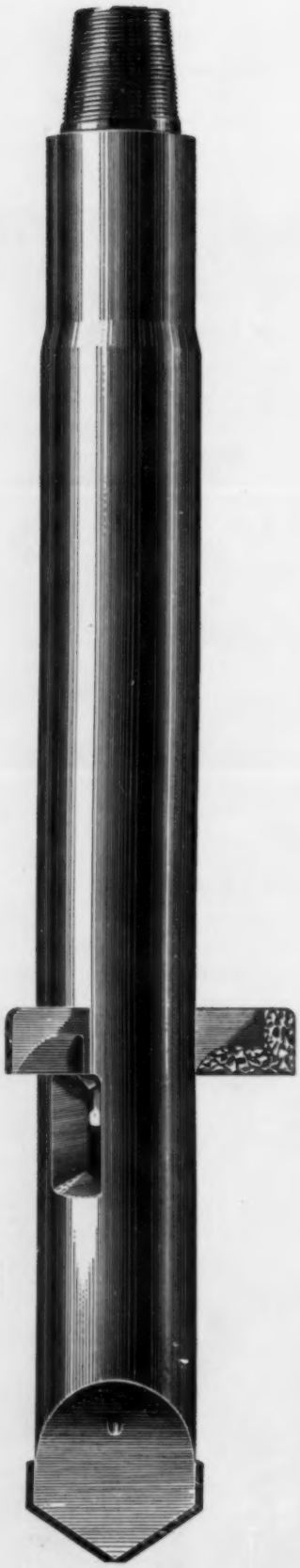
The flange-mounted main gear ring and the pinion shaft with its integral gear may be reversed for longer life. Gears are heat treated for maximum strength and toughness.

Timken double-row tapered bearings

... PRE-LOADED TO ELIMINATE BEARING SLAP

The crankshaft assembly is equipped throughout with high-capacity, long-life Timken double-row tapered bearings. Bearings may be hydraulically removed.





THE GRANT 3-BLADE WALL SCRAPER

This hydraulic expansion tool provides unsurpassed performance under the toughest hole conditions.

- Three blades give unequalled **stability,** prevent "torquing up"
- Down-hole **dependability** assured by minimum of working parts
- **Full circulation** to bottom
- Opening and closing of blades **controlled at the surface**
- Patented safety feature **assures retraction** of tool under any hole conditions

For the full story, write for Bulletin No. 60

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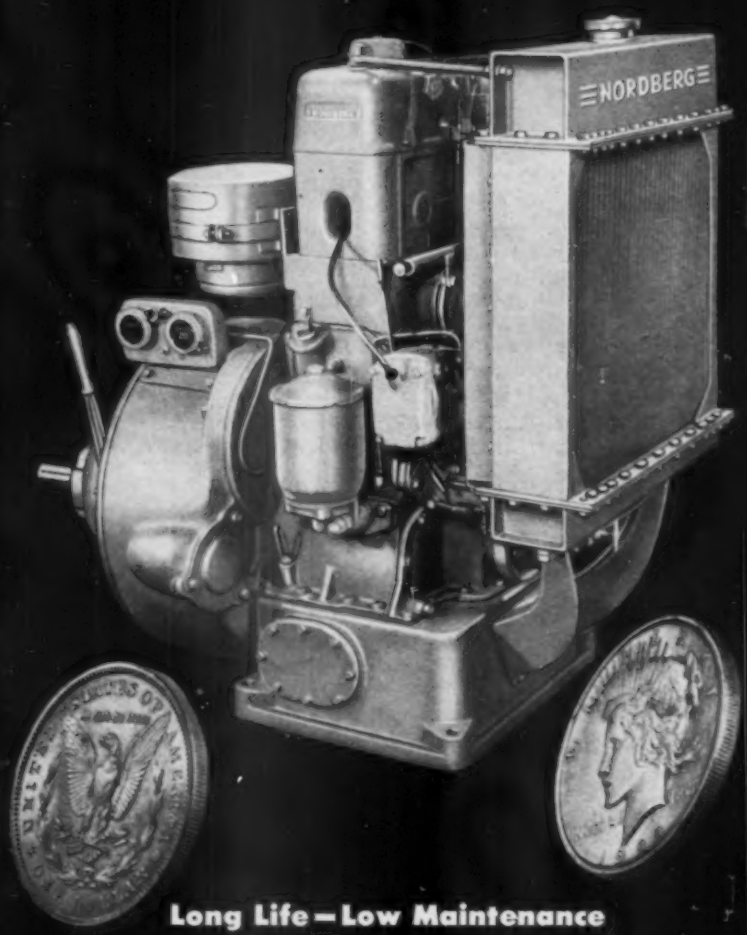


DOLLAR FOR DOLLAR...

NORDBERG

POWER CHIEF®

ENGINES

are your Best Buy for Oil Field Service

Long Life—Low Maintenance

These two important factors in the long run justify the soundness of your original investment in oil field pumping engines.

Before you buy your next engine consider the many service histories of Nordberg *Power Chief* engines that show over 30,000 hours of continuous pumping operation, with the original rings, pistons, liners, bearings and crankshaft still in place . . . this is real proof of value received for dollar invested.

Add to this the many "extras" such as enclosed clutch power take off and safety shut down control that are included as standard equipment on *Power Chief* engines and you will see why you save by specifying *NORDBERG*.

NORDBERG MFG. CO., MILWAUKEE, WIS.

CONDENSED SPECIFICATIONS

	ONE CYLINDER	TWO CYLINDER
Bore & Stroke	4½" x 5¼"	4½" x 5¼"
Piston Displ.	83.5 cu. in.	167 cu. in.
Compression Ratio	6 to 1	6 to 1
Speed Range	800 to 1800 rpm	800 to 1800 rpm
Horsepower	18 hp. max.	36 hp. max.

© 1957, Nordberg Mfg. Co.

NORDBERG

POWER CHIEF

DIESEL and GAS ENGINES

4-957-0

AVAILABLE AT YOUR LOCAL SUPPLY STORE — OR CONTACT THESE AUTHORIZED DISTRIBUTORS:

FRED E. COOPER, INC., Tulsa, Oklahoma
BRANCHES: Houston, Odessa, Olney
SALES & SERVICE: Casper, Wyo.; Corpus Christi, Longview & Wichita Falls, Texas; Lafayette, La.; Wichita, Kansas.

IN-MAR CO., Wilmington, California

STEPHENS OIL FIELD REPAIR, Fairfield, Illinois

MEAD ENGINE & WELDING WORKS, Sterling, Kansas

CORNELISON ENGINE MAINTENANCE CO., INC., Seminole, Oklahoma

ROGERS DIESEL ENGINEERING CO., New Orleans, La.

24-Hour Tour

America burns a lot of oil at midnight.

Maybe it's in the form of kerosene . . . in a lamp to light the shack of a trapper in the wilderness.

Or, perhaps it's the kind of oil that provides fuel for generators . . . generators that provide another kind of light and tremendous power for industries, power for the home.

Maybe the oil propels a ship, lights a buoy, keeps emergency vehicles operating.

People drill at midnight, too. They must, if the power needs of America are to be met.

They drill at noon, too; yes, around the clock.

They drill deep and shallow and tap big oil and gas pools and little pools.

All of this drilling—at all hours, in all weather, under all kinds of conditions—requires not just equipment, but specialized equipment. And equally important, specialized service.

That's why the Oil Center Tool Company has come to play such a big and vital part in the oil patches wherever they may be.

O-C-T equipment is precision-designed and engineered, precision-made and precision-installed.

Field service has distinguished the company as much as the equipment itself.

O-C-T field engineers and service men, as close as the telephone, always are available for expert installation at any location, at any time, in any weather.

The oil industry keeps hours . . . 24 in every day. And it drills and completes wells at all hours and in all places—next door to cities, but also in the marshes, in the mountains, under the ocean. Efficient field service is difficult, but an absolute necessity.

They get the job at hand done . . . quickly and efficiently.

But they're always looking ahead, these O-C-T men.

Completion problems of tomorrow are their problems.

That's why O-C-T field men keep such close contact with oil company engineers and drilling and production supervisors—to develop better equipment.

A problem encountered in the birth of a new oil or gas well today may mean the birth of a new O-C-T product tomorrow.

At midnight, noon or 4 A.M. in the coyote country of West Texas, the altitude of the Rockies, the marshes of Louisiana, the spray of the Gulf of Mexico, O-C-T men are available.

Available with the best techniques and the best equipment.

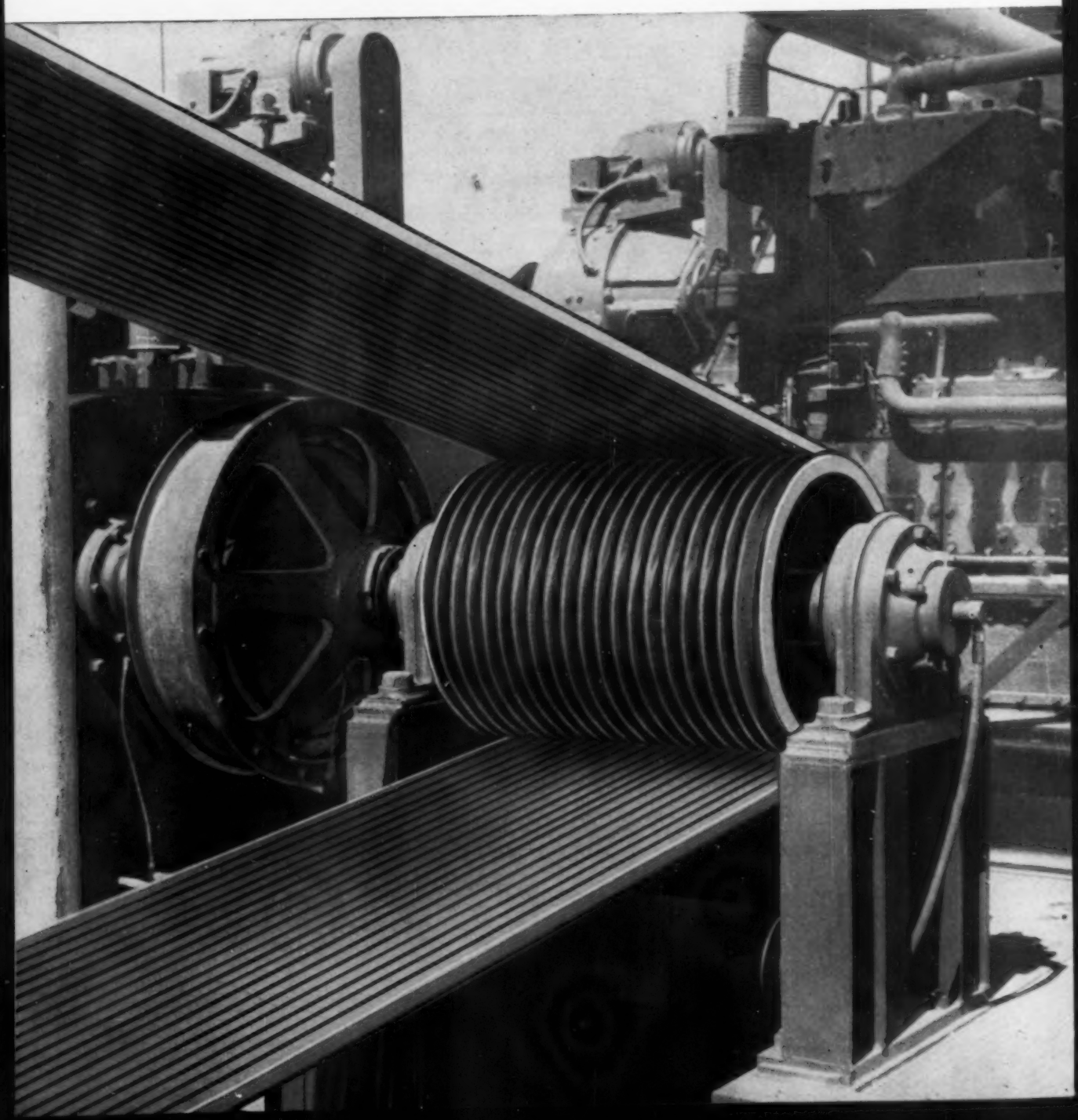
O·C·T

OIL CENTER TOOL CO.

Export Representatives: South America — East West Oiltools, C. A., Del Lago Hotel, Maracaibo, Venezuela. Address Export Inquiries for All Other Countries to P. O. Box 3091, Houston, Texas.

It's 9 p. m. The hanger is in place and the O-C-T Service Engineer at left is aided by a member of the drilling crew as the first unit of the well control system is put into place. At midnight this O-C-T man was on another well, in another field. He is always available, like all O-C-T service and sales personnel—regardless of the time or type of job.

WHY MULTI-MATCHED MAKE YOUR MAINTENANCE DOLLAR



DAYTON V-BELTS GO FARTHER

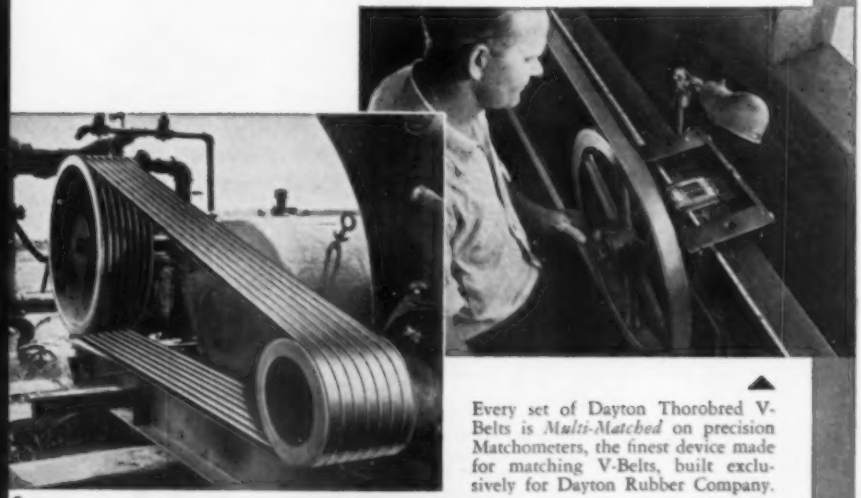
Precision matching assures long, uniform life for every V-Belt in a set

In transmitting power to mud pumps and draw works the service life of the *set* is the important thing. Premature failure of one or two V-Belts in a set is costly. And only when a set is accurately matched can it give the long trouble-free performance that makes your rig maintenance dollars cover more ground.

To be certain you get the longest possible service, Dayton *multi-matches* every set. Strict quality controls make every V-Belt as alike as possible in construction. Then they are matched in the factory on precision machines. Again and again at Regional and District Warehouses matching is checked and re-checked. Always the same type of precision equipment is used.

These matching machines, called Matchometers, are designed and built exclusively for Dayton. Their repeated use is your assurance that each Dayton V-Belt in a set will pull its share of the load.

Next time you order, remember *multi-matched* Dayton V-Belts. You can get them at over a hundred supply points.



Every set of Dayton Thorobred V-Belts is *Multi-Matched* on precision Matchometers, the finest device made for matching V-Belts, built exclusively for Dayton Rubber Company.

© D.R. 1957

World's Largest Manufacturer of V-Belts

Dayton Rubber

The Dayton Rubber Company, Industrial Replacement Div., Dayton 1, Ohio

Dayton V-Belts Available Through over a Hundred Oil Field Supply Points

DAYTON REGIONAL WAREHOUSES

Los Angeles, Calif.—909 East Slauson
Dallas, Texas—925 Slocum
Houston, Texas—1308 La Branch

DAYTON DISTRICT WAREHOUSES

California
Bakersfield—109 23rd St.
San Francisco—401 Howard St.

Louisiana
New Orleans—632 S. Peters St.
Shreveport—214 N. Market St.

Texas
Abilene—628-30 Walnut St.
Corpus Christi—1920 N. Port Ave.
El Paso—1701 Texas St.
Odessa—111 N. Lee St.
Pampa—159 S. Cuyler St.
Wichita Falls—1300 Indiana Ave.

Oklahoma
Tulsa—1124 East 4th St.

FIELD STORE STOCKS

Arkansas
All Republic Supply Stores

California
All Bethlehem Supply Stores
Bakersfield—Power Transmission and Equipment Co.
San Francisco—H. N. Cook Belting Co.

Colorado
All Republic Supply Stores

Illinois
All Republic Supply Stores

Kansas
All Republic Supply Stores
Coffeyville—Acme Foundry Co.

Louisiana
All Republic Supply Stores
Lake Charles—
Behring's Bearing Service of La., Inc.
New Orleans—
New Orleans Belting and Bearing Co.
Oil City—Oil City Hardware Co.
Shreveport—Bearing Transmission Co.

Nebraska
All Republic Supply Stores

New Mexico
All Republic Supply Stores

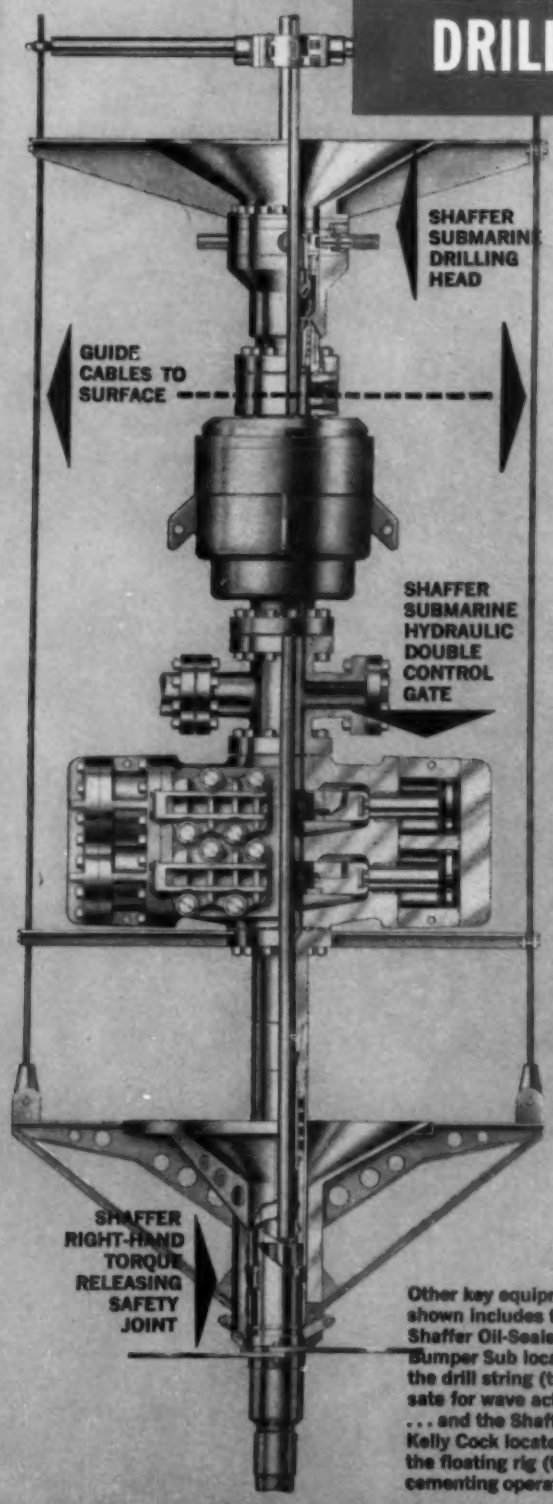
Oklahoma
All Republic Supply Stores
Oklahoma City—Green Head Service Co.
Tulsa—Engineering Supply Co.

Texas
All Republic Supply Stores
Abilene—Carpenter V-Belt Co.
Amarillo—Radcliff Supply Co.
Beaumont—Behring's, Inc.
Borger—Radcliff Supply Co.
Brownsville—Alamo Iron Works
Cisco—Walton Electric Co.
Corpus Christi—Alamo Iron Works
Bradley's Motor & Armature Works
Houston-Oil Field Material Co.
Stewart Dean Co.
El Paso—El Paso Saw & Belting Co.
Freer—Houston-Oil Field Material Co.
Houston—
Behring's Bearing Service Co.
Houston-Oil Field Material Co.
Kilgore—Jack Anderson Engine Co.
Lubbock—Lubbock Electric Co.
Bearing Specialists Co.
Lufkin—Lufkin Foundry & Machine Co.
Midland—Electric Motor Service Co.
Odessa—Duke Electric Co.
Pampa—Radcliff Supply Co.
Pearsall—Houston-Oil Field Material Co.
San Antonio—Alamo Iron Works
Wichita Falls—Mims Bearing Co.
Hornsby Heavy Hardware Co.

Wyoming
All Republic Supply Stores

Here's the Submarine Drilling Equipment That Is Revolutionizing the Industry!

THE SHAFFER SUB-SEA DRILLING HOOK-UP


SHAFFER SUBMARINE DRILLING HEAD
GUIDE CABLES TO SURFACE
SHAFFER SUBMARINE HYDRAULIC DOUBLE CONTROL GATE
SHAFFER RIGHT-HAND TORQUE RELEASING SAFETY JOINT

Other key equipment not shown includes the Shaffer Oil-Sealed Drilling Bumper Sub located in the drill string (to compensate for wave action) . . . and the Shaffer Type 55 Kelly Cock located on the floating rig (to simplify cementing operations).

Throughout the oil industry—wherever oil men are interested in drilling beneath the surface of lakes, bays, open ocean or similar locations—you'll find the new Shaffer Sub-Sea Drilling Procedure is making possible an entirely new approach to submarine development programs.

- Now exploratory work can be done from relatively inexpensive barges and converted landing ships instead of the costly drilling islands and special platforms heretofore required!
- Now the foundation problems of supporting drilling platforms on ocean beds and coastal shelves are eliminated because the drilling operations are conducted from a floating vessel!
- Now the storm and rough water hazards to equipment are minimized because drilling and landing equipment is on the ocean floor protected from exposure to the buffeting of surface waves!

Key to this new technique is the Shaffer Hook-up shown at left. Based upon Shaffer advanced pressure control units already field-proven in land-based operations throughout the oil world, this simplified hook-up permits the operator to drill and complete exploratory operations from the floating ship or barge . . . and to maintain pressure control from spud-in through plug-off. It sets entirely new standards of economy, speed and efficiency!

A 12 page brochure is available describing the equipment and procedures. Write for your free copy, or see your nearest Shaffer representative!

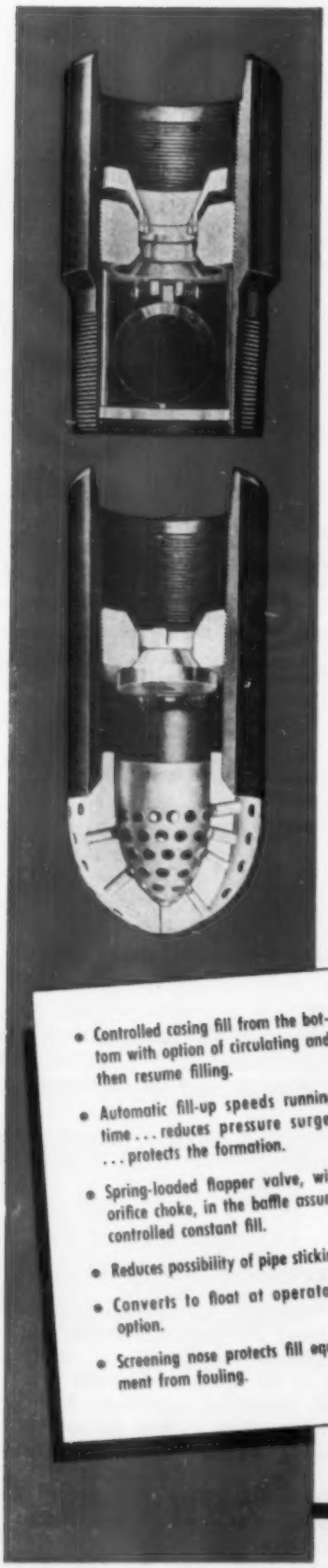
Shaffer equipment is described in the latest edition of your Composite Catalog.

SHAFFER

HIGH PRESSURE DRILLING AND CONTROL EQUIPMENT • FISHING TOOLS THAT EXCEL

SHAFFER TOOL WORKS, Brea, California • California Service Shops: Santa Fe Springs and Taft
HOUSTON, TEXAS, 6006 Navigation Blvd. • ODESSA, TEXAS, 1925 West Second Street
OKLAHOMA CITY, OKLAHOMA, Shaffer Tool Works, 6301 South Shields Boulevard
FARMINGTON, NEW MEXICO, Shaffer Tool Works, Post Office Box 546
CASPER, WYOMING, Shaffer Tool Works, Post Office Box 1788
EXPORT SALES OFFICE: Shaffer Tool Works, 500 Fifth Avenue, New York, N. Y., U.S.A.

34 years OF OIL TOOL LEADERSHIP



You're the Doctor

...when you run casing with

RECTOR TYPE "O"

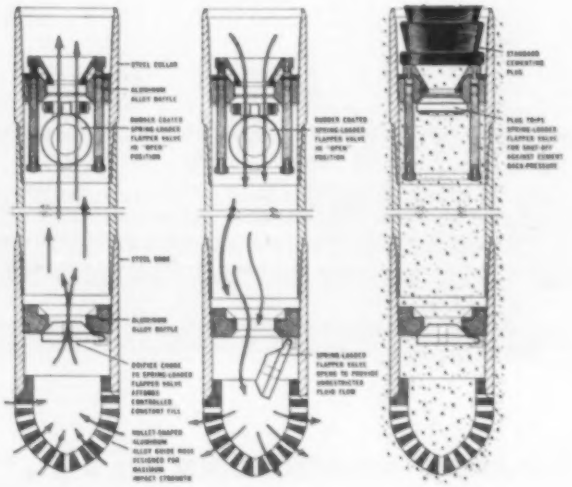
Optional Circulating
FILL SHOE and COLLAR

Rector Type "O" is the ONLY automatic casing fill-up equipment that permits circulating the well at your option, and then continuing to run pipe with controlled fill from the bottom. In cementing the well you use standard heads and plugs. The Type "O" collar provides positive shut-off against back-pressure.

If you need to convert from filling to floating, you can do so quickly by dropping in valve-trip ball at the surface and applying pump pressure.

Type "O" Fill Collars and Fill Shoes, used in combination, are priced competitively with other types of fill-up equipment which do not offer the Rector advantages of optional circulating, protective screening nose, and FULLY DRILLABLE ALUMINUM ALLOY all-metal construction. Prompt delivery through your favorite supply store in O.D. casing sizes from 4½" to 13⅜".

- Controlled casing fill from the bottom with option of circulating and then resume filling.
- Automatic fill-up speeds running time... reduces pressure surges ... protects the formation.
- Spring-loaded flapper valve, with orifice choke, in the baffle assures controlled constant fill.
- Reduces possibility of pipe sticking.
- Converts to float at operator's option.
- Screening nose protects fill equipment from fouling.



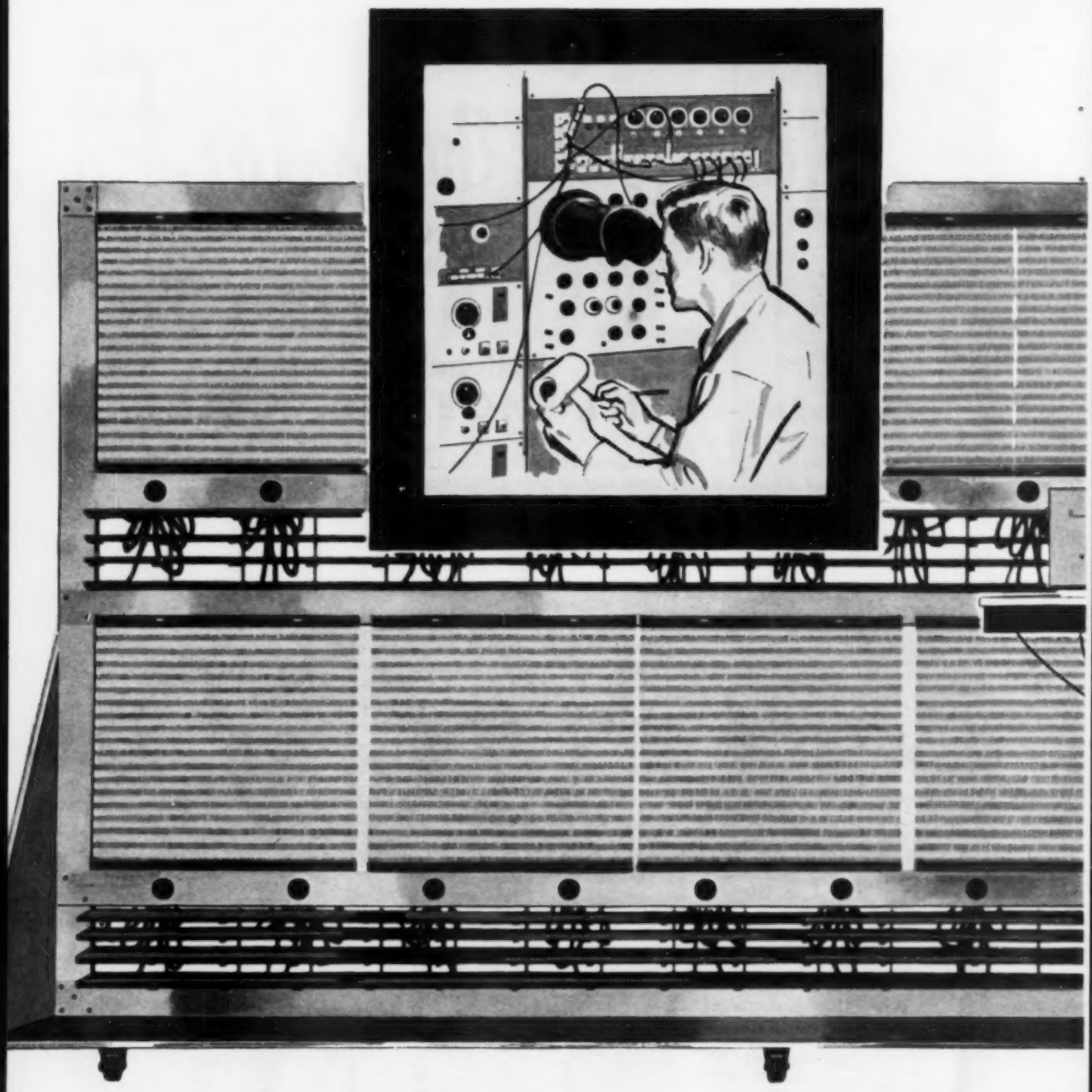
FILLING CIRCULATING CEMENTING

RECTOR WELL EQUIPMENT COMPANY INC

MAKING THE OIL INDUSTRY SAFER

1100 NORTH COMMERCE ST. FORT WORTH, TEXAS
Houston Plant: 2215 Commerce St.
REPRESENTATIVES IN ALL ACTIVE FIELDS

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



50,000 RESISTORS . . . . . "a researcher's oil well"

Rather surprising to think that formation characteristics can be duplicated in the laboratory, yet, it's done every day. A network of 50,000 resistors, in various combinations, is used to simulate bore hole parameters which affect resistivity measurements. All resistivity logs—including normals, laterals, micrologs, microlaterologs, and laterologs —can be studied.

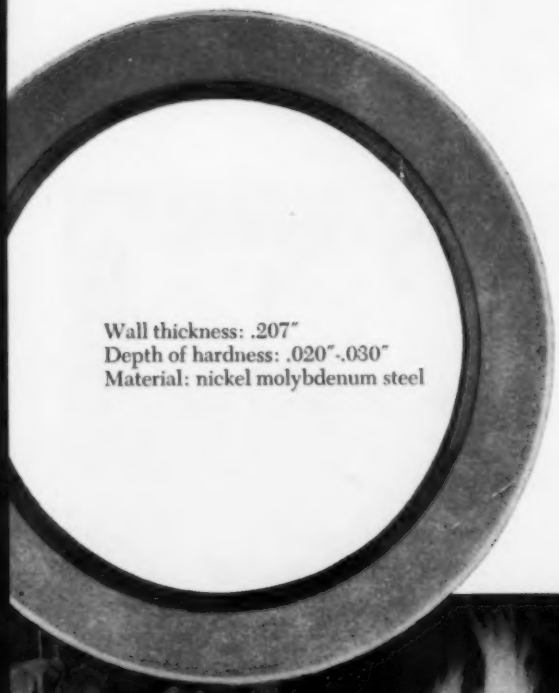
Such research techniques have made it easier for you to find oil and gas.

From Schlumberger's Research Center, located at Ridgefield, Connecticut, have come the logging devices, the advanced interpretation methods, the applications of physics to geology . . . all for better definition of oil and gas reservoirs.

At Ridgefield, laboratory experience is combined with field know-how to find the solutions to oil exploration problems. Through research, the answers to what might be needed in the future will be provided. They may be in the form of new tools, refinements of present tools, or new analysis methods.

The answers will come to you from Schlumberger.

SCHLUMBERGER . . . Engineering for Better Service



Wall thickness: .207″
Depth of hardness: .020″-.030″
Material: nickel molybdenum steel

Nickel Molybdenum Steel Barrels

FLAME-HARDENED DEEP

for Axelson Heavy-Wall Pumps

AXELSON HEAVY-WALL PUMP BARRELS are made from special nickel molybdenum steel that resists corrosion—particularly hydrogen sulfide. The tubing is flame-hardened to a depth of .020″-.030″. Subsequent low-temperature tempering relieves quenching strains, eliminates possibility of distortion. The result: The ideal unit for deep-well pumping. Strong, rigid and extremely resistant to corrosion and abrasion. One-piece tube won't flex or bind.

AXELSON PICTORIAL

AXELSON PLUNGERS RECOMMENDED FOR HEAVY-WALL PUMPS

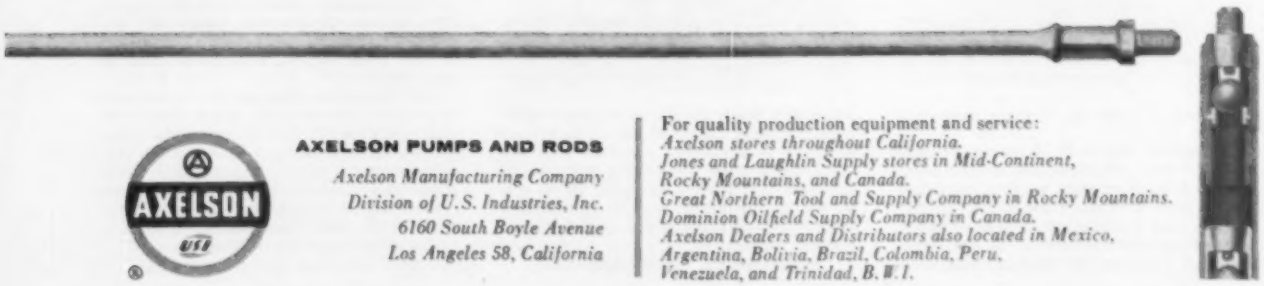
AXITE PLUNGER

New Axite one-piece plunger is a low-carbon steel tube sprayed with high-nickel-content hard-facing material to make it highly resistant to wear and particularly resistant to corrosion in hydrogen sulfide conditions. Surface hardness is Rockwell "C" 62.

COMPOSITE PLUNGER

Composite plunger is made of special-analysis iron, cast in precision sections, and assembled on a tube. Thus the plunger assembly is both corrosion and abrasion resistant. Surface hardness is equivalent to Rockwell "C" 55-60.

For complete information on Axelson Heavy-Wall Pumps, write to Department PP-8.



AXELSON

AXELSON PUMPS AND RODS

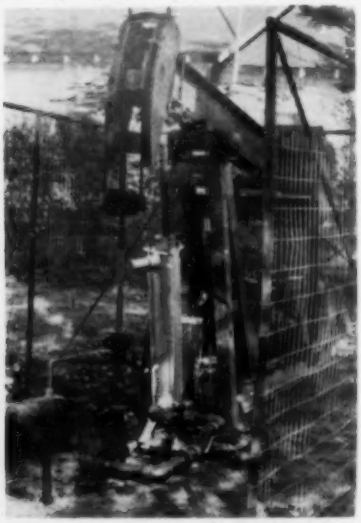
Axelson Manufacturing Company
Division of U.S. Industries, Inc.
6160 South Boyle Avenue
Los Angeles 58, California

For quality production equipment and service:
Axelson stores throughout California.
Jones and Laughlin Supply stores in Mid-Continent, Rocky Mountains, and Canada.
Great Northern Tool and Supply Company in Rocky Mountains.
Dominion Oilfield Supply Company in Canada.
Axelson Dealers and Distributors also located in Mexico, Argentina, Bolivia, Brazil, Colombia, Peru, Venezuela, and Trinidad, B.W.I.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS SEE READER SERVICE CARD

NEW Drilling and Producing Equipment

Need Gas? A new pumping unit attachment provides gas to run pump engines, heater treaters, etc., in gas short areas. Kilco pumping unit compressor is con-

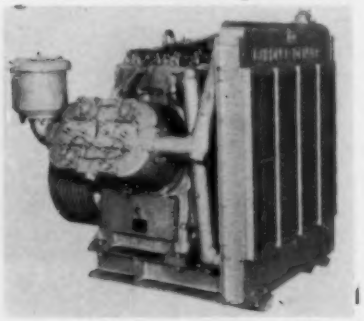


nected to the well annulus and by pulling a vacuum gains additional vapors and gas to run lease facilities. Simple in design, the compressor attaches to any pumping unit. Capacity is determined by stroke, pump speed and pressure requirements on the installation. Detailed specifications are available on request. *The Kilgannon Company.*

Circle number (1) on reply card.

Compact 200 hp Compressor. Gardner-Denver announced the addition of a new, high-capacity unit to its established WB line of air compressors.

This 200 hp, two-stage packaged unit occupies only 34 sq ft of space. In many instances it is sufficient to permit retire-



ment of 2 smaller compressors, with corresponding saving in space.

The WBN needs no special base. All that is required to put it into operation is to bolt it down and hook it up to its source of power. *Gardner-Denver Company.*

Circle number (2) on reply card.

Self-Propelled Air Drill. A rotary air drill mounted on a self-propelled air compressor has been developed by Schramm, for use in well drilling, blast hole drilling, seismic, and exploratory drilling. Known as the Pneumatractor Rotadrill, this compact unit features low original cost, convenient hole-to-hole maneuverability, and economical operation.

Rotary air drilling is accomplished through a reversible hydraulic motor-driven head, mounted on a carriage that rides tracks on the mast. This hydraulic drive eliminates the rotary table and Kelly bar. Hydraulic drive is smooth and undamaged by bit sticking. Holes can be drilled to 500 ft with 2⅞ in. OD flush drill pipe.

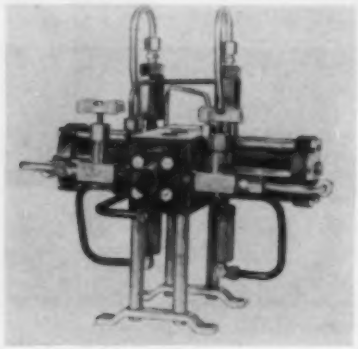
The Pneumatractor supplies compressed air at the rate of 150 cu ft per min at the drilling pressure of 10 psi. However, for dewatering or breaking out blockages, air pressure can be boosted to 125 psi. Speed of rotation is approximately 75 rpm, ideal for most types of rock.

Hydraulic control valves are located together, with pressure regulator and hy-

draulic gage for automatically controlling down feed. After the operator sets the feed rate, it is automatically maintained without clutching or continuous valve manipulation. *Schramm, Inc.*

Circle number (3) on reply card.

Glycol Drives Pump. Kimray, Inc. announces the addition of new Glycol Pump with double-action which eliminates high-pressure liquid-level controls on the absorber of glycol type of gas dehydrators.



Wet glycol from the absorber plus a small amount of gas (about 3 std cu ft per gal of glycol at 1500 psi) powers the pump.

Available with a working pressure of 1500 psi and capacities from 40 to 450 gal per hr, the pump has only two moving assemblies and forms a completely closed system. *Kimray, Inc.*

Circle number (4) on reply card.

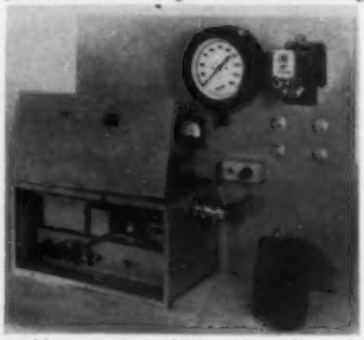
Head Geared for Low Pressure. A non-flanged casing head geared for low pressure wells, one that features compactness, ruggedness and economy, is one of the newer products of the Petroleum Industry Equipment Division of ALCO Products,

Inc. Known as the "LT Head," the compact head is available in sizes of 8⅝, 9⅝ and 10¾ in.

Packing seal is effected by tightening the cap screws in the packing assembly, causing the bottom ring to move away from the slips. This does not add to the slip load. A ring clamp holds the packing assembly in place. ALCO's LT Head has been tested to 3000 lb under the packing, a slip load test of 190,000 lb, equivalent to 8000 ft of 7-in. OD — 23 lb casing. *Petroleum Industry Equipment Division, ALCO Products, Inc.*

Circle number (5) on reply card.

Gas Flow Measuring. Designed by Computers Incorporated and sold through Oil Metering and Processing Equipment Corporation, new electronic gas flow system measures the flow of gas through an orifice plate by means of electrical signals proportional to the flow rate and accumulated flow. An adapter adjusts the instrument's calibration to the conditions of the measurement problem. Adjustments for changes in the measuring



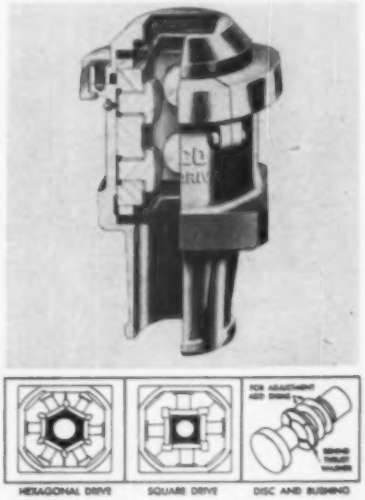
problem can be quickly and easily made by changing the "plug in" adapter.

The computer contains magnetic amplifiers, silicon diodes and transistors. Instrument is accurate to within 1 percent of full scale output with 20 percent or more flow.

The electronic computer has proved its practicality for metering use in automatic well testing systems, gas sales lines, gas transmission lines, gas distribution systems, and processing systems. The computer can also be used to control the flow of liquid or gas, and can be used to monitor the flow. *Oil Metering and Processing Equipment Corporation.*

Circle number (6) on reply card.

Rolling-Disc Kelly Lengthens Life. After more than a year of extensive field use a new type kelly drive employing unique "rolling-discs" as bearings has been placed in quantity production. A primary advantage of the new design is the tendency to smooth up and keep flat the driving surfaces of the kelly to assure smoother



feed-off and longer kelly life. The new design also lengthens the life of the kelly drive bushing as well as the kelly itself.

Because of the shape of the discs there is a large area of contact with the kelly rather than a tangent line of contact as in conventional roller-type kelly drives. Since the discs are positioned slightly off center from the centerline of the kelly they rotate along the flat side of the kelly as it is lowered. *Ideco, Inc.*

Circle number (7) on reply card.

Self-Aligning Coupling for Light Wall Tubing. Installation in 15 min or less is a feature of a newly patented coupling manufactured by Swepco Fittings. Designated as SWEPCO SS (Smooth Seal), it is intended for light wall stainless flow lines where corrosion is a factor. It is suitable for permanent or temporary connections, emergency repairs or for testing purposes.

No preparation is needed for pipe ends —only an open end or ratchet wrench is needed. A tapered gasket design and internal lip gives the smooth sealing action and provides an even interior surface.

Couplings are designed for working pressures of 100 psi and for pipe sizes up to 12 in. *Swepco Fittings, Inc.*

Circle number (8) on reply card.

Storm-Proof Heater. New indirect heaters featuring a storm-proof burner and pilot are available with input capacities (to water bath) from 90,000 Btu per hr to 4,000,000 Btu per hr. These units may be selected with either single or split coils in 1 to 6 in. sizes to handle pressures up to 6000 psi normal working pressure. Higher working pressure coils are available for over 8000 psi flowing pressures.

The burner and pilot used in Parkersburg indirect heaters is a simple, rugged, yet modern type of jet burner. Pre-heated fuel gas automatically mixes with the correct amount of air and burns at maximum "blue flame" efficiency. No air adjustments are necessary on this type burner.

With the primary air flow wide open, a simple turn of the positive-seat valve on the fuel gas line controls the amount of fuel gas as desired—and the correct air mixing is simultaneously adjusted by the burner itself. The pilot is a small scale jet burner which has the same operating characteristics of the burner itself. Tests conducted on these advanced types of jet burners and pilots have shown that high velocity crosswinds have no detrimental effect on either the burner or the pilot. *Parkersburg Rig & Reel Co.*

Circle number (9) on reply card.

Stainless Steel Solves "Fishing" Problem. A valve "fishing neck" made of a high alloy nonferrous metal, and used in underground oil well operations solves the "fishing" problem. When 17-4 PH (precipitation hardening) stainless steel replaced the material formerly used, it was found that it had the right hardness, strength and corrosion resistance to do the job with no costly delays in oil well operation. *Armco Steel Corporation.*

Circle number (10) on reply card.

Truck Equipment Sedan Pickup. New Sedan pickup has been especially adapted for field work by Truck Equipment Company. Designed primarily for oil field exploration crews, this pickup can be used by field party workers who demand extensive equipment. The basic truck was a F-250 Ford ¾-ton pickup. By lengthening the chassis and adding component parts to the cab, the standard F-250 becomes a Sedan pickup.

The Sedan pickup provides greater hauling utility, and a more comfortable seating of personnel. The pickup eliminates the need for two separate vehicles for hauling equipment and personnel. *Truck Equipment Company.*

Circle number (11) on reply card.

Foil Type Strain Gages. Easily-applied foil type SR-4 (bonded filament) strain gage is now available in 2 new types that provide fatigue life, sensitivity, and hysteresis characteristics superior to those of nearest equivalent bonded-wire SR-4 strain gages. Because foil gages are thinner and more flexible, they are more easily applied than wire gages, especially in fillets. They have always had an inherent attractiveness for stress analysis work, partly because of their freedom from external solder joints and partly because of lower cross-sensitivity to strain. To combine this attractiveness with superior performance, Type FAP-2 and Type FAB-2 foil strain gages have been developed. *Electronics and Instrumentation Division, Baldwin-Lima-Hamilton Corporation.*

Circle number (12) on reply card.

Pump Has High Output. A new positive displacement pump with rubber rollers acting as rolling vanes has been introduced by Hypro Engineering, Inc. This design reduces the friction normally associated with rotary, positive displacement pumps.

The new pump, which can be direct coupled to a gear reduced motor or engine, has 2-in. ports and delivers up to 95 gal per min at 700 rpm. Unlike centrifugal pumps, its output is not greatly reduced at higher pressures. In fact, at 40 lb pressure (92 ft head), pump output is still approximately 85 percent of the open discharge flow.

With synthetic rubber rollers, the pump is especially suitable for pumping water and many aqueous solutions. Anticipated uses for the new pump include fire control, flood clean-up, filling or draining tanks, pools, reservoirs, as well as many industrial liquid transferring uses. *Hypro Engineering, Inc.*

Circle number (13) on reply card.

New Lightweight Block. A new heavy duty Rigger-Slusher block is lighter than comparable blocks and practically shatter-proof. Made of high quality alloy steel, it will withstand 14-ton dead loads without damage. Wide flange permits use of up to and including ¾-in. wire rope.

Block has wide applications for rigging work because of its toughness and lightweight.

The Rigger-Slusher Durolite weighs only 44 lb and is available with roller or bronze bearings. Sheave diameter is 10 in. *Sauerman Bros., Inc.*

Circle number (14) on reply card.

New Diesel Electric Sets. Three portable diesel electric sets have been announced by Caterpillar Tractor Company. The new units are the Caterpillar D311, D315 (Series G), and D318 (Series G) diesel electric sets, each equipped with the new, compact Caterpillar Generator. The D311 electric set develops 30 kw of 60-cycle, 3-phase current, while the D315 (Series G) electric set is rated at 40 kw, and the D318 (Series G) electric set at 60 kw.

These highly mobile units are available either skid-mounted or with running gear, and the output of their self-regulated, constant-voltage generators furnishes a choice of 120, 240, 120/208 or 480-v current at 1800 rpm. Standard equipment on the sets includes 24-v, 18 amp charging generators and 24-v, 170 amp hr battery sets. The power units also come equipped with 24-v direct electric starting, wraparound bases, control panels and water temperature-oil pressure safety shut-offs. The 2 smaller sets have 50-gal fuel tanks, and the D318 (Series G) has a 57-gal fuel tank. *Caterpillar Tractor Co.*

Circle number (15) on reply card.

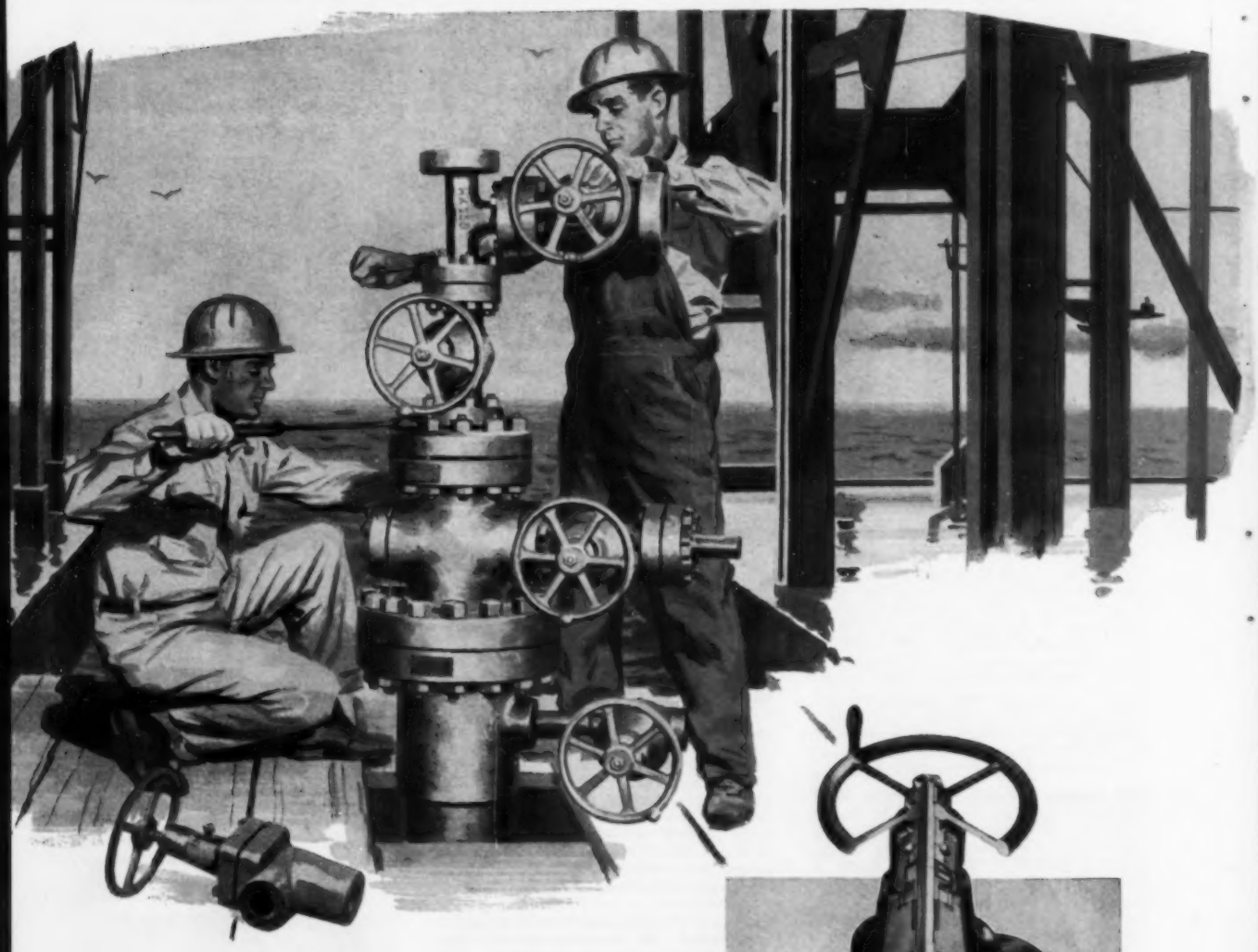
Field Mounting Quick Couplings. A new device makes on-the-job aluminum line-pipe connections practical and profitable with unskilled labor. New coupling tool is portable and simple to operate. Recent tests by line engineers in the petroleum, mining and chemical industries have proved its value.

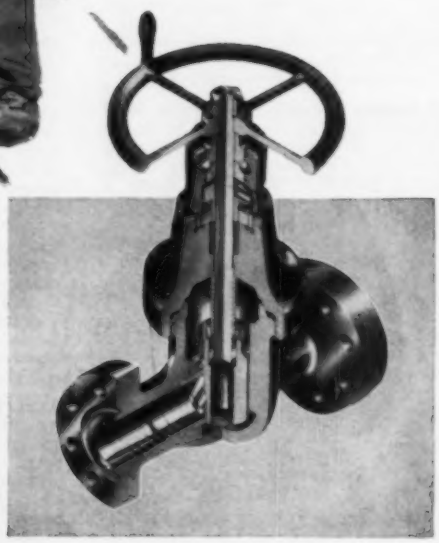
Manufacturers of Fast Move Couplers for aluminum line pipe pointed out that the portable tool is designed especially

for those who require custom in-field line installation. Only 4 simple steps are required for attaching Fast Move Couplers on-the-job: (1) Place pipe in saddle of flanging tool, (2) flip cam-action locking device and position FMC coupler, (3) turn ratchet-type handle clockwise to automatic stop, (4) release cam-action locking device and coupler is securely attached to pipe. *John Bean Division, Food Machinery & Chemical Corp.*

Circle number (16) on reply card.

Only the beginning . . . years of service ahead





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The BIW Valve is as easy to operate as it is positive. Only 25 foot-pounds of torque are required to open or close the 2½ in., 10,000 lb test valve against 5,000 psi pressure. And when it's closed you know it will hold.

ALCO specialists will show you the complete BIW Christmas tree with proved BIW Non-Lubricated Gate Valves.

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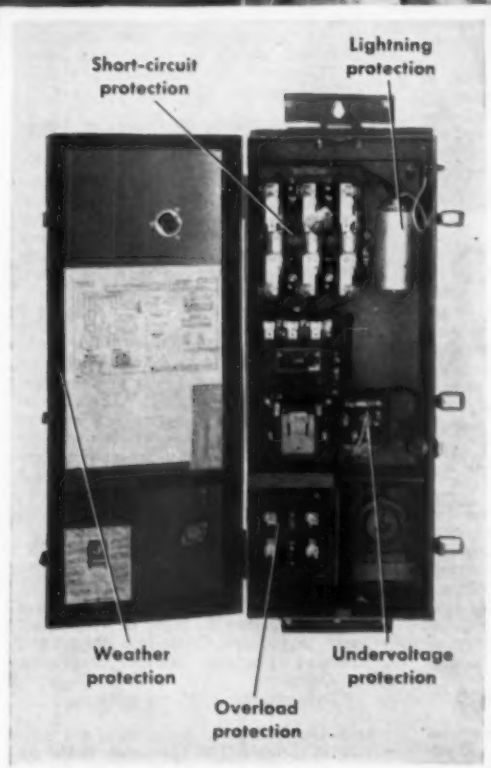


PROTECTIVE FEATURES provide electrical and mechanical protection for equipment and personnel.

GENERAL ELECTRIC OFFERS 5 FEATURES FOR . . .

Easy Mounting...Easy Wiring with G-E Oil-well Starters

General Electric oil-well pumping starters contain five mounting and wiring features that make them easier for you to install on your pumping rigs. These five features are:

- **COMPACT, LIGHTWEIGHT UNITS.** The light weight of these G-E oil-well pumping starters through Size 2 makes them easy for one man to carry and mount.
- **WING-TYPE BRACKETS.** A keyhole slot in the top bracket supports the starter while bolts are secured in the top and bottom bracket.
- **TALL, NARROW SHAPE.** Enclosure is shaped to fit the pole, and is easier to handle during installation.
- **VERSATILE WIRING.** An interchangeable conduit hub at the top, and four combination knockouts in the bottom make wiring easy.
- **LIFT-OFF DOOR.** The enclosure door opens a full 180 degrees—but if desirable split hinges allow you to lift off the door.

FOR COMPLETE INFORMATION on G-E oil-well pumping starters, contact your nearest General Electric Apparatus Sales Office or Distributor. Or, write Advertising Section 733-27, General Purpose Control Department, Bloomington, Ill. Ask for bulletin GEA-6410.

GENERAL ELECTRIC

NEW Literature

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Impervious Graphite Entrainment Separator. The new "Karbate"® brand impervious entrainment separator is described in a 4-page bulletin available from National Carbon Company, division of Union Carbide Corporation. Discussing the simple construction of the non-clogging type MV unit, the bulletin explains how the efficient, corrosion-resistant equipment separates entrained liquids from gas streams.

Tables list separation efficiencies at average flow rates for various liquid particle sizes from 1.7 to 11.0 microns, and give complete unit dimensions, working pressures, and entrained liquid capacities for the 6 sizes of separators available. *National Carbon Company.*

Circle number (17) on reply card.

Booklet on Lithium. "Presenting Lithium," a 15-page tabbed booklet, has just been issued by the recently formed American Lithium Institute. Booklet describes the properties, uses, research potentials, and availability of lithium and its unique compounds and discusses the function of the Institute itself.

The current uses of lithium and its compounds in ceramics, automotive greases, air conditioning, welding and brazing are reviewed as are applications in alkaline storage batteries, metals refining, and organic synthesis. As potential areas for lithium research, booklet suggests the development of stronger glasses with improved electrical properties; the development of whiteware ceramics and refractories with better thermal shock resistance; the manufacture of new and workable light alloys; as well as the modification of heterogeneous catalysis and studies of polymerization and other catalytic organic reactions. *American Lithium Institute, Inc.*

Circle number (18) on reply card.

Help for Compressed Air Users. The contamination present in all air that comes from compressors, the damage it causes, and the simple, inexpensive way by which the Logan Aridifier prevents such trouble is the subject matter of this new Logan Engineering catalog. Users of pneumatic tools and spray equipment will especially be interested in the Aridifier's removal of 92 percent of all moisture, oil, dirt, and fine scale in the air line before such foreign matter takes its costly toll in damaged equipment and fouled work.

Operated by the compressed air passing through it, the Aridifier impales the foreign matter on whirling rotor blades, then hurls the impurities by centrifugal force against the inside wall of the unit. *Aridifier Division, Logan Engineering Co.*

Circle number (19) on reply card.

Fluoroscopy with Image Intensification. A new 6-page folder which describes modern techniques for applying fluoroscopy in metal examinations, is available from the Instruments Division, Philips Electronics, Inc. Well-illustrated with photos, drawings and graphs, the folder clearly explains the mechanism of image intensification, effect of target size on the X-ray image, and penetration effectiveness for various methods.

The new literature also covers radiography techniques with the Norelco 360-deg X-ray tube, the double fractional focus X-ray tube, and the MG-300 installation. Several photos show how image intensification is applied in a plant where automatic welds are inspected in ½ in. steel at the rate of 10 ft per min. *Instruments Division, Philips Electronics, Inc.*

Circle number (20) on reply card.

Condensed Bulletin on Steam Traps. This 4-page bulletin is a complete condensed buying guide on steam traps, containing specifications, capacities, sizes, pressures, weights, and list prices of all principle types of Super-Silvertop Traps. Construction and operation of these inverted type traps are described. The outstanding features are reviewed which includes a patented guided bucket, installation straight inline or as an elbow, easily removed Anderloy valve and seat, reverse flow and self-cleaning feature. Data are also contained on self-cleaning strainers. *The V. D. Anderson Company, division of International Basic Economy Corporation.*

Circle number (21) on reply card.

Metallic Epoxy Putty. A 4-page illustrated bulletin published by the Smooth-On Manufacturing Company describes their A2 series of aluminum-filled epoxy resin compounds. These products are designed for use in marine and metal-working industries and for any repair or maintenance activity requiring a chemically-stable, non-shrinking, and nonflammable putty with good adhesion to iron, steel, aluminum, wood, glass or ceramics.

Bulletin 11 outlines many uses of Metalset and describes its numerous advantages, such as ease of mixing, convenient room-temperature curing, and machinability. In addition, detailed illustrated descriptions are given as to how the oil and waterproof material should be used for successful application. *Smooth-On Manufacturing Company.*

Circle number (22) on reply card.

Telemetering System Catalog. Just off the presses is an outstanding catalog describing the various components used in the "Varec" pulse code telemetering system. Contents include overall description of systems and complete line of temperature converters, receivers, selectors, remote control transmitters, remote selectors, and transmitting measurement devices. *The Vapor Recovery Systems Company.*

Circle number (23) on reply card.

Emulsion Treater Bulletin. An 8-page multicolored brochure on their Type "P" Emulsion Treater has been published by Moran Tank Company. Flow descriptions and features of these units are described and amply illustrated throughout. In addition, complete information on shell sizes, capacities, working pressures, and other engineering data is presented in tabular form at the end of the booklet. *Moran Tank Company, Inc.*

Circle number (24) on reply card.

Cementing and Fracturing Equipment. Available to export operators is a new catalog of Byron Jackson equipment for oil well cementing, fracturing and servicing. This 40-page catalog contains photographs, dimensional drawings and specifications of more than 20 models of BJ equipment. Included are truck-mounted and skid-mounted high pressure, high volume pumping units for cementing and fracturing; sand-oil blenders; bulk equipment; conveyors and cement heads and plugs.

Byron Jackson stresses that this equipment is only for sale outside the United States. Within the United States many of the cataloged models are used in the oil well servicing operations of BJ Service, Inc. — Chemical Process. *Byron Jackson Tools, Inc.*

Circle number (25) on reply card.

Crown Blocks. Crown blocks for all well drilling requirements are presented in Bulletin No. 470, newly issued by National Supply Company. Design features and complete specifications for five sizes ranging from 120 to 525 tons capacity are presented with illustrations. *The National Supply Company.*

Circle number (26) on reply card.

New Industrial Tire Book. A 36-page illustrated guide book that explains all phases of industrial tire use has been published by B. F. Goodrich Tire Company. Written for maintenance superintendents, industrial engineers and purchasing agents, the book describes: (1) The complete Goodrich line in detail, (2) the use of each type of industrial tire, (3) the variations in pneumatic tire capacities at various speeds, (4) the wheel and caster combinations available, (5) the latest available truck manufacturers' tire specifications, and (6) how to change steel wheels to rubberized wheels in three easy steps. *B. F. Goodrich Tire Company.*

Circle number (27) on reply card.

Portable Aluminum Buildings. A 4-page brochure has been issued on the new all aluminum buildings manufactured by M&P Inc. Designed for portability, applications include field offices, mud houses, bunk houses, and other oil field uses where utility buildings are required. Brochure includes standard specifications and information plus list of present users. *Aluminum Company of America.*

Circle number (28) on reply card.

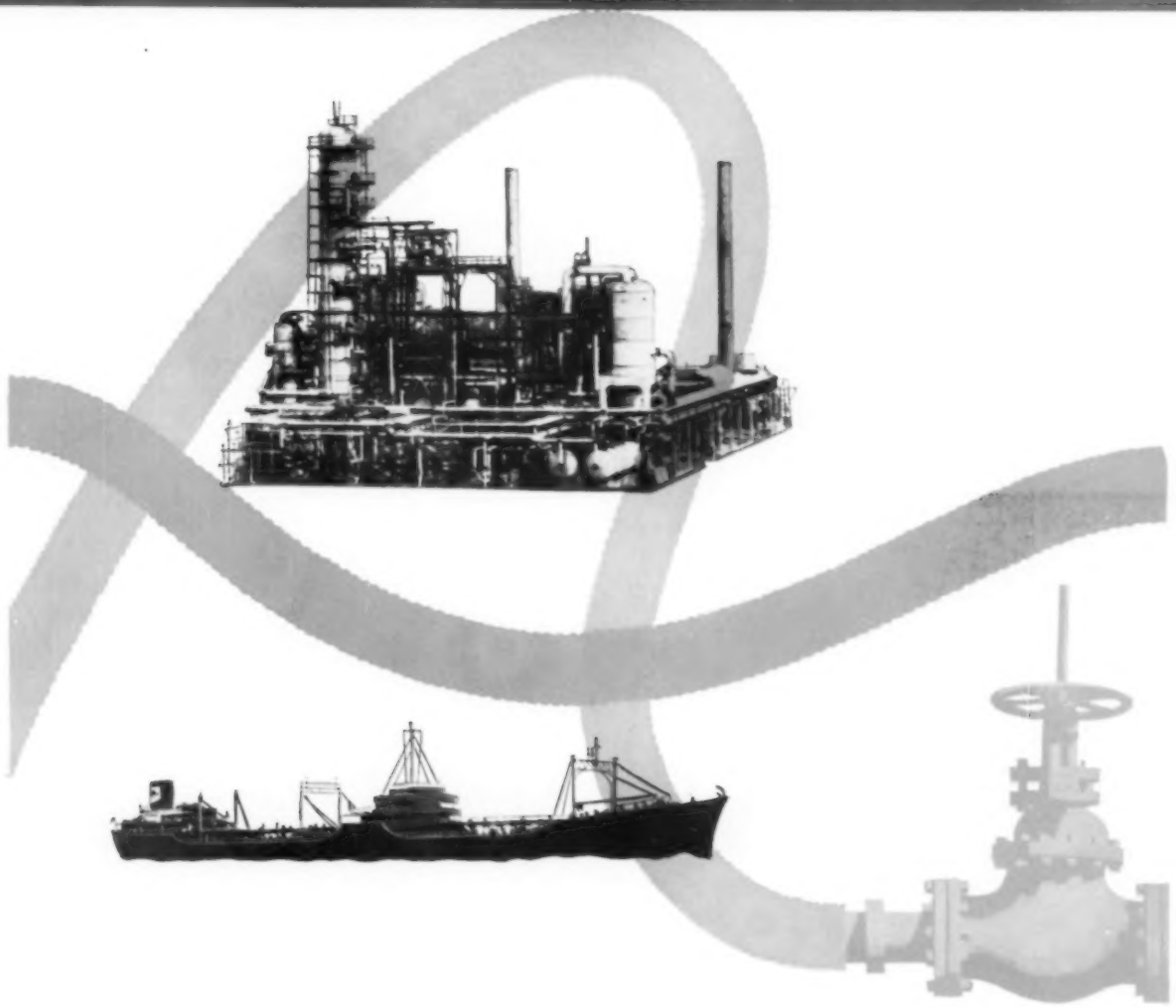
Ideas for Increasing Efficiency. Free booklet shows 59 shortcuts to speed drafting and computation work. Post went to leading engineers and draftsmen and asked them what techniques they use to save time without sacrificing precision in their work. From the many interesting tips and drafting shortcuts suggested, a total of 59 have been compiled into one booklet called "Time Saving Tips for the Draftsman and Engineer."

Clearly written and well illustrated, booklet shows new approaches to old problems. The section on Calculating Ideas contains 10 tips including easy ways of "Remembering the Signs of Trig Functions," "Dividing a Circle Into Parts," and "Locating Decimal Points." *Frederick Post Company.*

Circle number (29) on reply card.

Tank Gages. Just off the press is a 4-page bulletin giving full and complete detail on the construction operation of the Oceco No. 30 tank gage. Said to be highly accurate, easy to read, readily adapted to remote reading and easily installed on either new tanks or tanks already in service. The unit uses the float principle in tank level measurement. *Oceco Division, Johnson & Jennings Co.*

Circle number (30) on reply card.



Sun Ship has furnished equipment for many major oil companies in America

Of essential importance to American welfare is the free, expanding progress of the Oil Industry. Tankers for many of the oil companies have been built in the Sun Ship Yard. Also, refining equipment repairs and replacements have been furnished for the major oil companies.

In addition, Sun builds special machinery and fabricated steel products for a variety of other industries whose problems have been a welcome challenge—readily accepted—easily solved. Call or write our Sales Engineering Department about your plans—or problems. Immediate, courteous attention is assured.

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Why **DYNALOG*** *design is out front of all electronic potentiometers . . .*

IT GIVES STEPLESS, CONTINUOUS BALANCING!

Advance features to improve control of temperature, pressure, flow . . .

1. No periodic maintenance
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Here's precision in motion . . . the smooth, continuous balancing action of a Dynalog Electronic Instrument! No slidewire with faltering step-by-step inaccuracies . . . no sliding or rubbing contacts. Instead, a simple, variable, radio-type capacitor and positive magnetic drive. It's friction-free, wear-free.

That's why Dynalogs respond almost instantly to the slightest change in a process variable, with a sensitivity of 1/100 of 1% of scale . . . accuracy of ¼ of 1% of scale. It's also the reason they're the maintenance man's dream. About all he does is supply ink and charts!

Dynalogs are used with any primary element—resistance, voltage, capacity, inductive. They perform with effortless accuracy, even on control and recording problems that conventional balancing-type instruments can't handle. For the complete story, write for Bulletin 20-10. **The Foxboro Company, 389 Norfolk Street, Foxboro, Mass., U.S.A.**

*Reg. U. S. Pat. Off.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

New Projects in refining gas processing petrochemicals

The Cooperative Refinery Association will have The Refinery Engineering Company build a $1 million HF alkylation unit at its Coffeyville, Kansas, refinery. The process is licensed by Universal Oil Products Company. Construction will start in September with completion set for early 1958.

Frontier Refining Company will up the capacity of its Cheyenne, Wyoming, refinery to 22,000 BPD; present capacity is 16,500 BPD. Plans also call for doubling asphalt unit capacity to 10,000 BPD. Metropolitan Life Insurance Company is financing the project with a $1.5 million loan.

Cabot Carbon Company plans to have a new, 3.5 MMcf per day gas processing and liquids recovery plant onstream in Lea County, New Mexico, by the end of the year. The installation will cost about $1 million.

E. I. duPont de Nemours will double high-pressure polyethylene capacity as part of the company's 1957 expansion. New products may include low-pressure polyethylene and polyformaldehyde plastic.

Esso Standard Oil Company will build a marketing data-processing center in a Baltimore, Maryland, suburb. To serve all of the company's sales divisions covering 18 states, equipment will include an IBM 705 electronic computer to handle accounting and statistical work. There are seven 705's now in oil industry operation, with two of them being used by Esso, at Baton Rouge, Louisiana, and Linden, New Jersey.

Sinclair Oil & Gas Company will install a deisobutanizer at its gas products plant at Covington, Oklahoma. The unit will process 20,000 gal per day of butanes, with the isobutane to be shipped by tank truck for use as refinery alkylation unit raw material. The Covington plant processes 18 MMcf per day of gas, produces 55,000 gal of liquid products daily.

British American Oil Company's new refinery at Port Moody, near Vancouver, B. C., is now in the initial stages of construction. Scheduled for completion by late 1958, Canadian Kellogg, an affiliate of M. W. Kellogg Company, will build the topping, vacuum, cat cracking, cat reforming, hydrodesulfurization, and alkylation units.

British Petroleum Company's German associate (BP Benzin-und Petroleum GMbH) and Farbenfabriken Bayer are joining forces to build a petrochemical plant adjacent to the Bayer plant at Dormagen, near Cologne. Plans call for a total expenditure of $56 million over a period of time. About 300,000 tons per year of petroleum feedstock will be used in the plant's cracking units, will be supplied from a new BP refinery to be built in the Ruhr area. Semi-finished products will be produced.

Imperial Chemical Industries, English petrochemical giant, is contemplating a $280 million complex in Gloucestershire. Construction is a long time away, though—in the mid-1970's. Both organic and inorganic chemicals will be produced.

Anlin Company of New Jersey will build and operate a sulfur recovery unit adjacent to California Oil Company's refinery in Perth Amboy, New Jersey. To be completed by the end of this year, the plant will process 7-million cubic feet of refinery fuel gas daily.

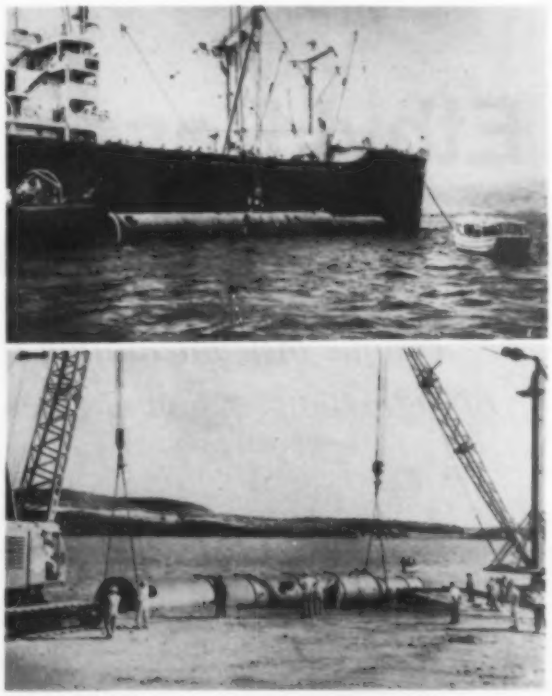
See Page A-10 for Onstream Announcements.

Union Carbide Corporation will build its eighth major chemical producing plant in Putnam County, West Virginia, to be completed in 1960. Major products will be ethyl alcohol and 150 million lb per yr of ethylene oxide. Most of the production of these petrochemicals will be shipped to other Union Carbide chemical plants to make finished products.

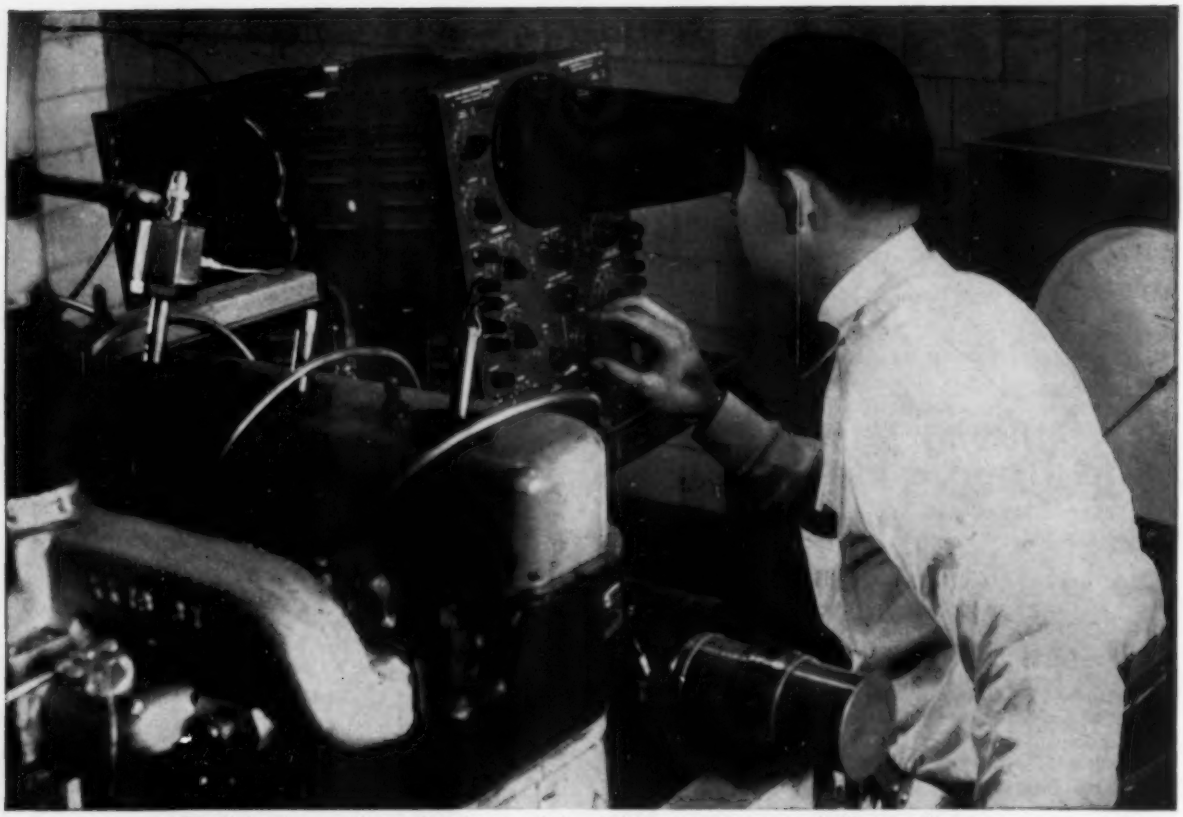
International Rubber Company, Ltd. is building England's first synthetic rubber plant. Design and construction of the new facility, which is adjacent to the Fawley refinery of Esso Petroleum Company, Ltd., is being done by Blaw-Knox Company, Chemical Plants Division. Capacity will be 50,000 long tons of GR-S a year.

Standard Oil Company (Ohio) has given a $2.4 million contract to Arthur G. McKee & Co. for construction of an alkylation unit. The unit will be erected at the Cleveland No. 1 refinery and will use a M. W. Kellogg Company process design. Maximum charge rate will be about 5500 BPD; the corresponding alkylate production will be almost 3600 BPD.

Petroleos Mexicanos will build a 15-million lb per year low-pressure polyethylene plant in Mexico City. To be operated under license from Phillips Petroleum, the new plant should be operating by 1959. A cat cracker is now under construction at the Pemex refinery.



LST — landing ship, tower — solves logistics problem. Faced with a problem of transporting the atmospheric tower of the 20,000 BPD crude fractionating unit to Texaco's Santiago, Cuba, works, Procon International, S.A. used the tower as its own landing ship. The 103-ft long tower was towed ashore by a tug and hoisted ashore by two cranes, as the lower picture shows. The refinery is being built by Procon for The Texas Company (West Indies) Limited, a wholly owned subsidiary of the parent company.



This Ethyl engineer matches crank angle time with the cylinder pressure pattern on a dual beam oscilloscope.

Ethyl Research Measures True Engine Friction

Unique instrumentation used to study the advantages of high-compression engines and their octane requirements

by R. E. Gish

Technical Service Division, Ethyl Corporation Research Laboratories

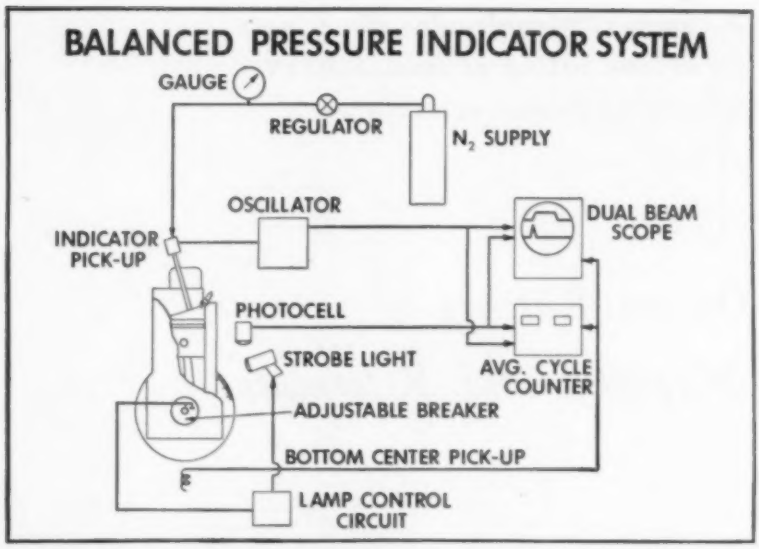
TWO NEW DEVICES for measuring friction in an automobile engine during operation have been developed by Ethyl Corporation's Research Laboratories to improve the accuracy of studies of high-compression engine behavior.

These studies are being conducted as part of a continuing effort to preserve a reasonable relationship between the advantages of high-compression engines and their octane requirements.

The unique instruments make obsolete a method of approximating power-robbing friction losses by measuring the amount of power required to drive a non-firing engine.

This approximation does not take into account the effects of combustion pressures and temperatures which are present only during actual operation. Using the new instruments together, true engine friction can be determined accurately.

(Advertisement)



A schematic drawing of the electronic measuring system for measuring true engine friction.

Mechanical Efficiency Maintained as Thermal Efficiency Increases

Differences between true and motoring friction were studied in a four cylinder, overhead valve engine at compression ratios of 7.0 to 1 and 12.0 to 1. This engine was selected because attractive gains in power and fuel economy had been obtained with increased compression ratios in a previous test program. These results offered ample evidence of the engine's structural rigidity.

Test results verified that motoring friction does not provide a firm guide to true engine friction; motoring friction was both significantly higher and lower than true friction in the various tests.

Variations in peak cylinder pressure are averaged as the engine runs on this "average cycle counter."

This research program also showed that, although friction increased with compression ratio, the mechanical efficiency of the engine during full-throttle operation was only 1.5% lower at the 12 to 1 compression ratio than at 7 to 1.

Thus, it appears that mechanical efficiency can be maintained almost constant as thermal efficiency increases throughout this compression ratio range.

It was shown, in addition, that certain worthwhile improvements in brake horsepower can be obtained from relatively small increases in mechanical efficiency.

Equally significant, the limiting ratio for improvements in brake horsepower and fuel economy appears to be well above the 12 to 1 ratio as the curve of brake thermal efficiency versus compression ratio shows no sign of leveling off at 12 to 1.

Electronic System Includes New Pressure Measuring Equipment

One of the new instruments is a specially-designed, balanced pressure indicator that compares cylinder pressure with a known reference pressure. The second new device is an "average pressure" computer which averages the cycle-to-cycle variations in pressure in the peak pressure region and establishes the corresponding crank angles.

Both are also used in conjunction with a dual beam oscilloscope and associated electronic equipment to obtain a visual indication of the relation between cylinder pressure and crank angle.

The data obtained permit accurate plotting of the pressure-volume relationships in an operating engine.

Thus, indicated horsepower can be determined directly. Since brake horsepower is measured simultaneously, friction horsepower can be determined by subtraction. (Indicated Horsepower – Brake Horsepower = Friction Horsepower.)

This study is typical of the many ways in which Ethyl uses its unique position as liaison between the Oil and Automotive industries. The underlying purpose of all such long range studies is to help engine designers take maximum advantage of high compression and still hold octane requirement to a reasonable level.

How Ethyl Research is helping you

More than 30 years of intensive fuel and engine research experience and extensive research facilities enable Ethyl to contribute to the progress of both the oil and automotive industries.

The instruments and technique described here are just one product of this experience and these facilities.

As always, our Technical Representatives, backed by the extensive facilities of Ethyl's Research Laboratories, want to share their knowledge with your technical people.

Your Ethyl Representative will welcome the opportunity to arrange an appointment for you.

Send for your free copy of our technical paper entitled, "Determination of True Engine Friction." Address your request to Ethyl Corporation, 100 Park Avenue, New York 17, N. Y.

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RESEARCH LABORATORIES:
1600 W. Eight Mile Road, Ferndale 20, Mich.
2600 Cajon Road, San Bernardino, Calif.

Laboratory studies show that a commercial molecular sieves unit would boost catalytic reformate octane rating at least 5 RON without total yield debit. An attractive payout is indicated

Molecular Sieves *Boost Octane Ratings of Light Naphtha and Reformate*

William C. Ziegenhain

REFINERS, faced with the ever-increasing problem in producing higher octane number motor fuels at reasonable operating cost and yield levels, may find a part of the answer with a relatively new product "molecular sieves." So-called because of their ability to separate liquid and gaseous materials on the basis of molecular size, one type of "sieve," known as 5A, will selectively adsorb lower-octane normal paraffins from multi-component streams such as catalytic reformate, light virgin naphtha, and natural gasoline.

Reported here are the results of bench-scale studies on the adsorption and desorption characteristics of molecular sieves. In addition to work with the binary system of toluene and n-heptane, studies were made with process streams: Light virgin naphtha, catalytic reformate, and catalytic cracked naphtha.

A subsequent economic study, made on a "screening" basis, shows that a commercial molecular sieve unit, proposed herein, would show a very attractive return — nearly 20 percent after taxes. The unit would process 4500 bbl per day of catalytic reformate having a leaded Research octane number (RON) of 94, with the effluent rated at 99 RON at 3 cc TEL. The adsorbate . . . removed by heating and purging with an oxygen-free gas . . . would be about 450 bbl per day of C_5 through C_{10} n-paraffins.

What are Molecular Sieves?

Fully described in the February 1957 issue of *The Refining Engineer*, p-C-53 molecular sieves are synthetic zeolites with a definite crystalline structure containing a large number of cavities. These cavities are interconnected by still smaller pores that are precisely uniform in size.

These cavities and pores try to regain the water molecules that were driven off in manufacture. In the absence of water, they will adsorb any molecule that is small enough to get in. Larger molecules are "rejected."

The developers and manufacturers of molecular sieves, Linde Products Company, has two sizes available: Type 4A, which will accept molecules not greater than four Angstroms in diameter, and Type 5A, which will adsorb molecules of a diameter of less than five Angstroms. The adsorption characteristics of both types are shown in Table 1.

Research Program

A series of semi-pilot plant runs were made with Type 5A sieves at varying space velocity with two different mixtures of nitration-grade toluene and n-heptane, and with catalytic reformate, light virgin naphtha, and catalytic cracked naphtha.

The equipment is shown in Fig. 1. The 48 in. by 1 in. column was packed with 403.0 grams of 1/16 in. diameter Type 5A molecular sieves and wrapped with heating tape. Nitrogen was used as a purge gas and the desorbate condenser was filled with dry ice and acetone (−110 F) to assure complete recovery of the original charge stock.

Experimental work was divided into three phases as follows:

1. Determination of equilibrium capacity for n-heptane in a static system,
2. Capacity of sieves at specific liquid charge rates with synthetic charges stock of known composition, and
3. Passing multi-component mixtures through the adsorption bed to determine the extent and type of n-paraffins adsorbed. Product quality effects were also measured.

Equilibrium capacity for n-heptane was found to be 11.44 weight percent in a static test conducted at rigidly controlled conditions. This is slightly higher than the value of 11.3 weight percent determined by Linde in their work.

Degree of separation of n-heptane from nitration grade toluene was determined with two synthetic blends having these physical properties—the normal heptane used was ASTM normal heptane with a refractive index of

TABLE 1. Adsorption Characteristics of Molecular Sieves.

4A and 5A	Adsorbed on 5A, not 4A	Can't get "in"
Water	Propane and higher	Iso-paraffins
Carbon Dioxide	n-paraffins up to	Iso-alcohols
Carbon Monoxide*	at least C_{14}	Aromatics
Hydrogen sulfide	Butene and higher	Naphthenes
Sulfur Dioxide	olefins	Cyclic paraffins
Ammonia	n-Butanol and higher	above C_3
Nitrogen,* Oxygen*	n-alcohols	Carbon tetrachloride
Methane,* Menthanol		Boron trifuloride
Ethane, Ethanol	Cyclopropane	"Freon" 114
Ethylene, Acetylene		"Freon" 11
Propylene, n-Propanol	"Freon" 12	All molecules larger
Ethylene Oxide		than 5.0 Angstroms

*Appreciable quantities are adsorbed only below −20 F.

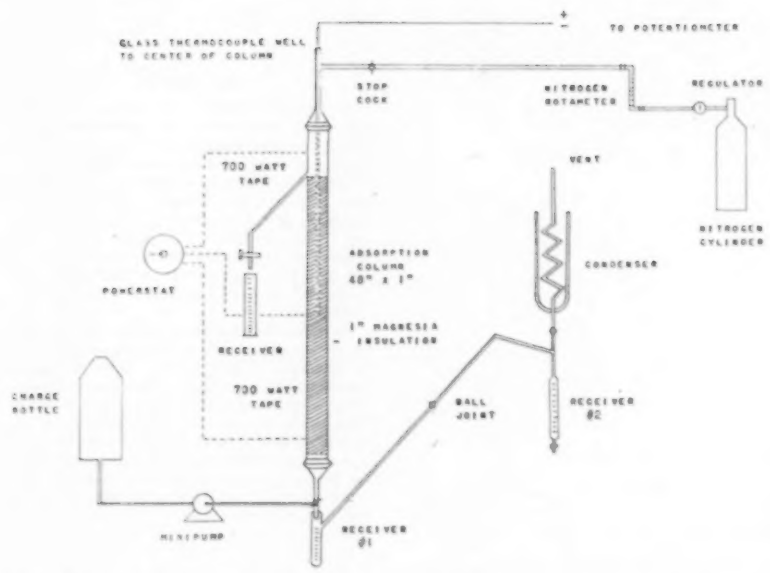

FIG. 1. Schematic diagram of semi-pilot plant equipment.

1.3878. Literature reports the refractive index of normal heptane to be 1.38765. The nitration grade toluene used had a refractive index of 1.4960 with literature reporting 1.49685. The toluene used was also analyzed on a mass spectrometer and found to be 99.1 percent toluene by volume—the blends were as follows:

	Runs 1-4	Runs 5-8
Weight percent n-heptane	5.00	10.00
Volume percent n-heptane	6.25	12.34
Weight percent toluene	95.00	90.00
Volume percent toluene	93.75	87.66
n_D at 68 F	1.4888	1.4818

Results of the runs are shown graphically on Fig. 2, 3, and 4. They were made at atmospheric pressure and initial bed temperature of 77 F. No attempt was made to maintain the sieves at isothermal conditions; a temperature rise of 20 F was noted during runs 1-4. During runs 5-8 the rise was 20-25 F.

Cuts of the effluent were collected frequently to determine the breakthrough point of n-heptane in the effluent. The breakthrough point was determined as that point during the run when the refractive index of the effluent toluene was lower than the refractive index of the original nitration-grade toluene. Normal heptane content was evaluated from the n-heptane/toluene refractive index correlation shown in Fig. 5.

As the figures show, the breakthrough point of the n-heptane was dependent upon the liquid charge velocity and the concentration of n-heptane in the charge. Yield of n-heptane-free product decreased as liquid velocity increased . . . probably due to decreased residence time in the column . . . and the yield also decreased with increasing concentration of n-heptane in the feed. The sieve loading varied from 7.5 to 9.3 weight percent during these runs.

As shown in Fig. 2 and 3, the refractive index values of the initial toluene effluent were higher than the refractive index of the original nitration grade toluene indicating the removal of impurities with a refractive index lower than that of toluene. This development was the basis for a later run (No. 12) in which nitration grade toluene was the charge stock to the column in an attempt to isolate and identify the impurities present that had not been detected by the mass spectrometer. From results of the run it was established that the contaminant was normal octane and was present in the nitration grade toluene to the extent of 0.54 volume percent.

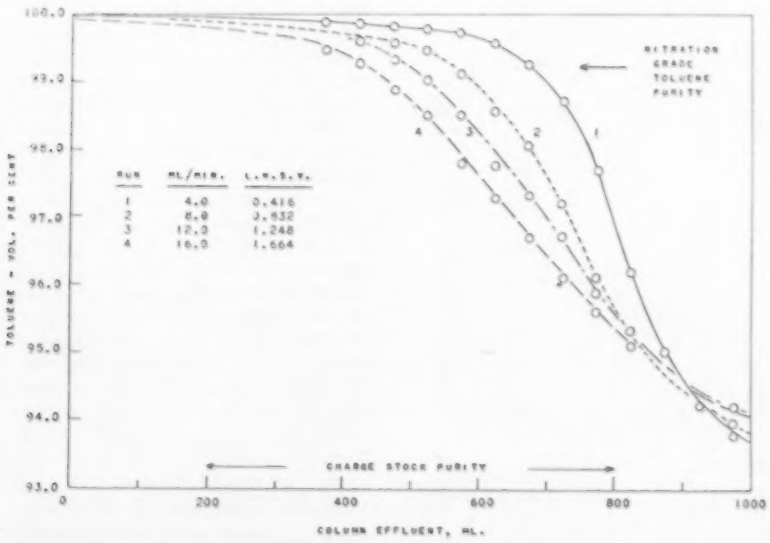

FIG. 2. Separation of normal heptane from 5.0 wt percent normal heptane in nitration grade toluene.

Regeneration

Proper regeneration of the sieves is quite important since their high cost and relatively low capacity require their reuse to make a process economically feasible. In many cases, also, the adsorbed material is the desired material to be recovered and must be readily desorbed from the sieves with a minimum loss in yield or alteration of physical properties.

The regeneration or reactivation may be attained by various methods — the best known seems to be the simultaneous heating and purging of the sieves with an inert gas. Temperatures required will depend on the material adsorbed but will usually run from 300 to 700 F. Inert gas is required, particularly at the elevated temperatures, to prevent having an explosive mixture present, as would be the case if air were used. Oxidation of the desorbed materials would also be serious at the elevated temperatures since the sieves have been reported to have a catalytic activity.

Another suitable regeneration technique is simultaneous heating and evacuation with the aid of a vacuum. This method permits the regeneration to take place at a lower temperature level and would be useful for the recovery of strongly adsorbed materials which are heat sensitive and physically unstable at high reactivation temperatures. Disadvantages of

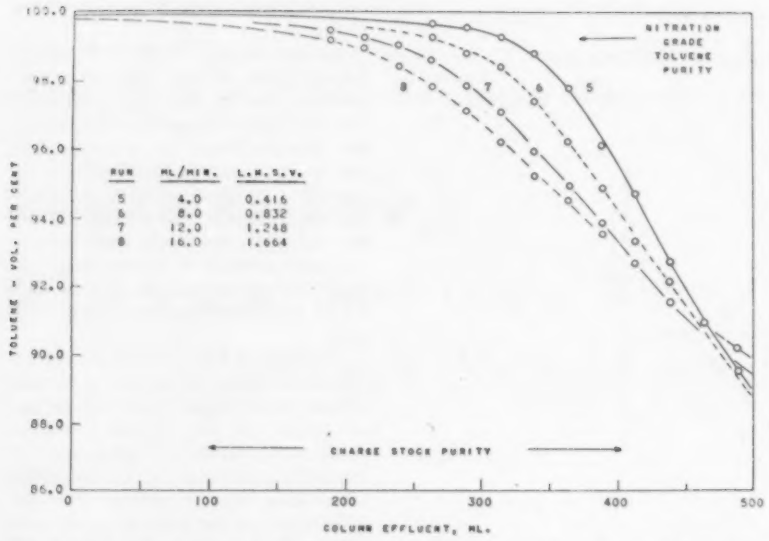

FIG. 3. Separation of normal heptane from 10.0 wt percent normal heptane in nitration grade toluene.

The Author

William C. Ziegenhain has had an interesting and varied experience in the oil refining industry. After receiving a bachelor of science degree in chemical engineering from the University of Oklahoma, he took an engineering post with the then Tidewater Associated Oil Company at their Drumright, Oklahoma, refinery. When the plant shut down in 1955, he became an associate chemical engineer in the process laboratory at Continental Oil Company's R & D department at Ponca City, Oklahoma.

He completed the requirements for the master of science degree in chemical engineering at Oklahoma A & M in May 1956. He joined the staff at Amoco Chemical Company's Brownsville, Texas, installation on February 1, 1957. This article presents a major portion of his master's thesis, submitted under same title.

A devoted family man, Bill managed to put the finishing touches on this article while helping out his wife shortly after his little daughter was born in early June.

this method are the poor heat transfer rates to the sieves due to the vacuum and lack of a flow of purge gas to distribute the heat evenly through the bed and minimize the presence of hot spots from the heating equipment.

Displacement of the adsorbed materials by a material more strongly adsorbed is a third method of desorption. Water or steam would displace all other types of materials as the sieves have the greatest affinity for water molecules. Water displacement would be most suitable for materials extremely sensitive to heat. After complete displacement by the water molecules the sieves could then be regenerated by a normal heating and purging cycle.

The method followed in all of the experimental runs consisted of first draining the column, then slowly heating the sieves while passing nitrogen through the bed to evaporate the extraneous liquid from the column without desorbing the sieves. A sharp temperature rise in the sieve bed would be noted when the column was dry and successive column vapors were passed to the dry ice and acetone condenser bath to recover the desorbed materials. A purge rate of approximately one space velocity per minute was main-

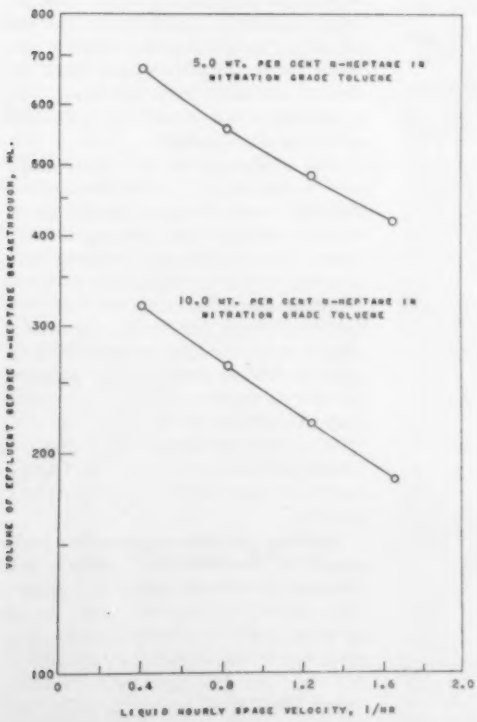
5.0 WT. PER CENT n-HEPTANE IN NITRATION GRADE TOLUENE
10.0 WT. PER CENT n-HEPTANE IN NITRATION GRADE TOLUENE
VOLUME OF EFFLUENT BEFORE n-HEPTANE BREAKTHROUGH, ML.
LIQUID HOURLY SPACE VELOCITY, 1/HR

FIG. 4. Effect of concentration and charge rate on the breakthrough of n-heptane.

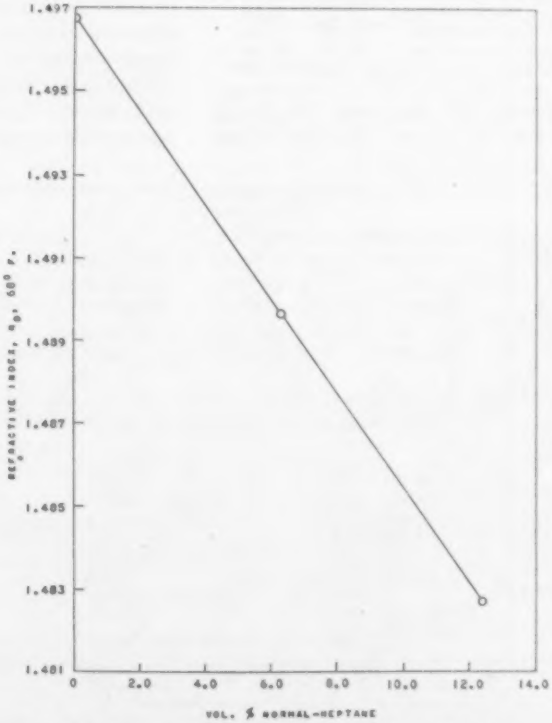

FIG. 5. Refractive index of normal heptane-toluene blends.

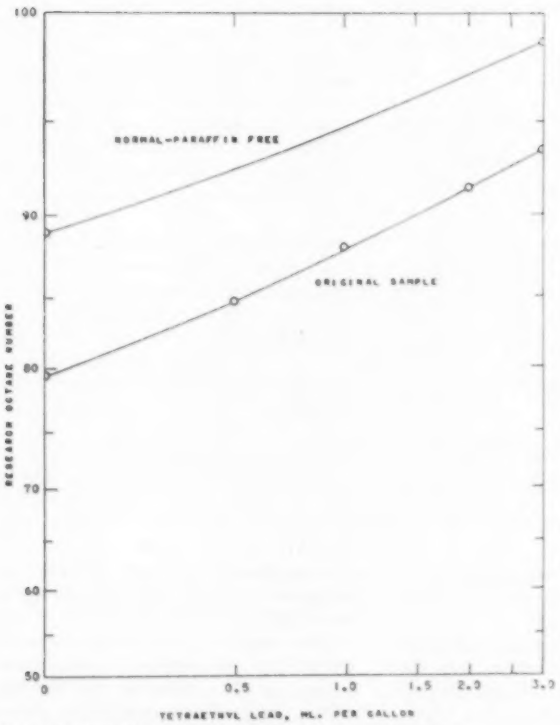

FIG. 6. Tetraethyl lead susceptibility of catalytic reformate.

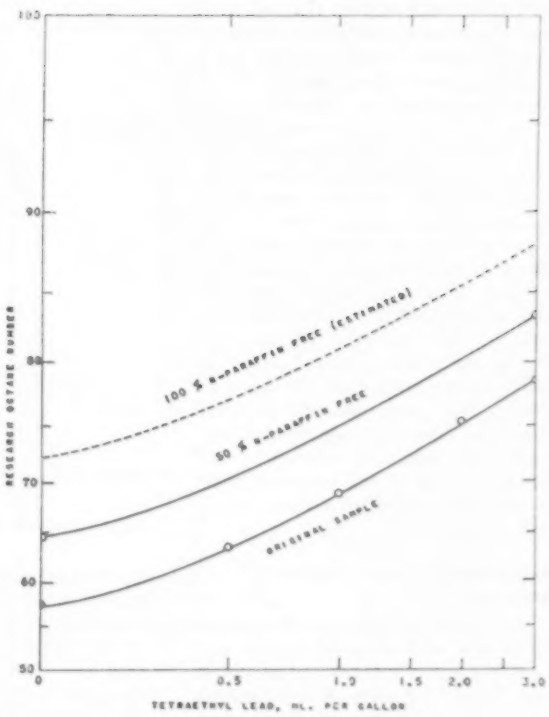

FIG. 7. Tetraethyl lead susceptibility of light naphtha.

tained during the desorption period along with a heating rate of 5 to 10 F increase every minute until a bed temperature of 660 F was attained. At that point the heat was adjusted to maintain that level while the purge continued for one additional hour. In all cases the amount of condensate recovered the final half-hour of the regeneration cycle was nil.

The final sieve loading as determined from the amount of desorbed material recovered in runs 1-8 is presented in Table 4. The inconsistent variation in sieve loading as the space velocity was increased in runs 2, 3, and 4 was probably due to lack of familiarity with the equipment since the results of runs 5-8 were more consistent.

Equilibrium adsorption or maximum capacity for the test conditions was approached but not attained as indicated in Fig. 2 and 3 therefore the sieve loading values in Table 2 do not represent a maximum attainable value. The refractive indices on the desorbed materials are slightly higher than the refractive index of the ASTM normal heptane due to the presence of normal octane adsorbed from the nitration grade toluene. This may be substantiated by the results from runs 5-8 when only half as much toluene was passed through the column thus admitting less normal octane to the sieves.

Heats of desorption were not evaluated in this work but an indication of

TABLE 2. Material Recovered from Desorption of Molecular Sieves on Runs 1-8.

Run No.	Normal-heptane recov		Sieve loading	n_D at 68 F
	vol-ml	wt-gms	wt percent	
1	53.0	36.4	9.0	1.3889
2	44.1	30.4	7.5	1.3888
3	46.9	32.3	8.0	1.3892
4	47.9	32.9	8.2	1.3889
5	54.4	37.4	9.3	1.3882
6	51.0	35.1	8.7	1.3882
7	51.3	35.3	8.8	1.3882
8	49.6	34.1	8.5	1.3882

TABLE 3. Experimental Data on Catalytic Reformate.

Physical Tests	Catalytic reformate	Effluent composite	Desorbed material
API Gravity	53.9	50.6	73.0
Reid Vapor Press. psi	2.9		
n_D at 68 F	1.4300	1.4377	1.3896
ASTM Distillation, F			
IBP	135	—	156*
5%	175	—	176
10%	178	—	183
20%	200	—	192
30%	210	—	200
40%	220	—	205
50%	231	—	212
60%	244	—	218
70%	257	—	226
80%	276	—	237
90%	301	—	260
95%	325	—	292
EP	363	—	338
Recovery, ml	98.5	—	97.0

*Based on 50 ml of sample.

		Refractive index Values, 68 F	
Cut No.	Fraction	Run 9	Run 10
1	0-100	1.4378	1.4376
2	100-200	1.4388	1.4383
3	200-300	1.4378	1.4374
4	300-400	1.4350	1.4342

their magnitude may be realized from the temperatures required to reactivate the sieves. Normal heptane has a boiling point of approximately 209 F at standard conditions, however, it was found that little if any normal heptane was desorbed at 209 F and over one-half of the adsorbed materials were not recovered until the bed temperature reached approximately 550 F. The vapor pressure of normal heptane at 550 F is approximately 500 psia. The normal heptane therefore was well above its critical temperature of 512.6 F before the desorption of the sieves was at a maximum rate. Increasing the purge rate would probably have reduced the temperatures required slightly — however, calculations indicated that increased losses from the condenser due to the increased purge flow would reduce the volume of materials recovered.

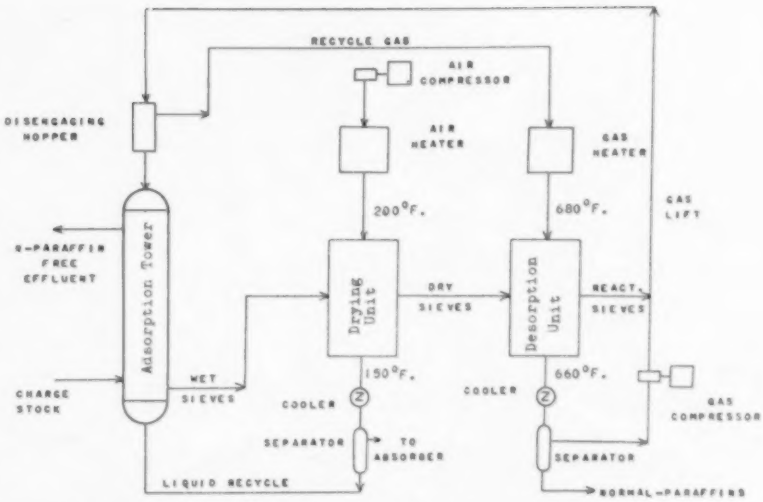

FIG. 8. Schematic diagram of proposed "Parasorb" unit.

Adsorption from Refinery Streams

To determine if the sieves could isolate materials from plant streams containing a wide variety of hydrocarbons, runs 9 and 10 were made with catalytic reformate as the charging stock. Analysis of the reformate indicated 46.1 percent paraffins, 1.0 percent olefins, 14.5 percent naphthenes and 38.4 percent aromatics. Physical tests of the reformate and products obtained from the run are presented in Table 3 and Fig. 5.

The amount of normal-paraffins present in the reformate was determined to be approximately 10.0 percent of the original volume or approximately 22 percent of the total paraffin content. The boiling range of the normal-paraffins was similar to that of the original reformate. The improvement in Research octane number of the column effluent or "sievate" was considerable as shown in Fig. 5. The increase of almost 10 octane numbers indicates that about one octane number increase may be expected from the removal of one volume percent normal paraffins. As might be expected the improvement in the leaded octane ratings is not as notable. The increase of 5.2 octane numbers was achieved however without a decrease in total product yield. To achieve the same increase in octane numbers in present catalytic reforming units would result in a considerable product loss and reduced catalyst life.

Light virgin naphtha. Runs similar to those made on the catalytic reformate were made on samples of light virgin naphtha sampled directly from a crude oil processing unit. The light naphtha contained 50.1 percent paraffins, 0.9 percent olefins, 46.7 percent naphthenes, and 2.3 percent aromatics. Physical properties of the charge stock and products are presented in Table 4 and Fig. 6.

The amount of normal paraffins present in the light naphtha was determined to be approximately 16 percent of the original volume or 32 percent of the total paraffin content. The high paraffin content drastically reduced the volume of normal paraffin free sievate that could be obtained from each run. Therefore, sufficient cuts were blended to permit octane numbers to be run on a blend containing 50 percent of the normal paraffins originally present. The results are presented in Fig. 6.

Results obtained from the runs on the light naphtha were similar to those obtained on the catalytic reformate. The octane improvement on the unleaded samples amount to about one number improvement for each volume percent of normal paraffins removed. The boiling range of the normal paraffins was comparable to the boiling range of the original charge stock.

Catalytic naphtha. Only one run was made on catalytic naphtha due to difficulties encountered on regeneration. The sample was taken directly from a catalytic cracking unit and analysis indicated the naphtha contained 27.5 percent aromatics, 8.3 percent olefins, 14.0 percent naphthenes, and 50.2 percent paraffins.

Refractive index readings on successive cuts of the sievate indicated materials were being removed by the sieves. The octane number of the product was 88.8 with the octane number of the original charge stock being 87.4, indicating only slight improvement due to the treatment. On regeneration very little condensate was recovered while a considerable amount of non-condensible white smoke with a pleasant odor was emitted from the condenser when the temperature reached 600 F in the sieves.

The regeneration difficulty is attributed to the improper regeneration technique. It is believed the normal olefins present in the catalytic naphtha were strongly adsorbed and polymerized and thermally decomposed on heating during the regeneration cycle. Further studies were not made since the octane improvement was not considered significant. A more successful regeneration could have been obtained if the adsorbed materials had been displaced with water and then the sieves had been heated and purged.

"Parasorb" Unit Proposal

To provide further information on the feasibility of utilizing molecular sieves in a commercial process, an economic study was made. The name "parasorb" is a coined word to identify the process. Purpose of the unit would be to remove the low octane number normal-paraffin components from catalytic reformate to provide a superior motor fuel.

Capacity of the unit would permit processing 4500 bbl per day of catalytic reformate into 4050 bbl of upgraded normal-paraffin free product and 450 bbl per day of normal-paraffins. The yields are based on the results obtained in the experimental studies on samples of catalytic reformate. The charge stock would have an unleaded octane rating of approximately 80 and a leaded octane rating of 94. The upgraded product would have an octane rating of 89 unleaded and 99 leaded. Further processing of the normal paraffins in a suitably designed catalytic reforming unit or by hydroisomerization would permit an even greater yield of premium quality product.

One assumption was made — that future developments in the manufacture of the molecular sieves will provide a new type of molecular sieve as a spherical pellet with high resistance to abrasive action. This feature would permit the use of a moving bed of sieves in an adsorption tower and continuous regeneration in suitable equipment.

The use of pellets is not mandatory, since the sieves could be used as a powdered slurry and handled accordingly. The process principles would be the same, but continuous filtration equipment would be required.

Process description. A schematic diagram of the proposed unit is presented in Fig. 8. The weight of molecular sieves in the total system would be approximately 100,000 lb. The circulation rate of the sieves would be 76,000 lb per hr, with a normal-paraffin loading of 6.0 weight percent on leaving the adsorption section. The adsorption tower would contain approximately 45,000 lb of sieves. The fresh feed of catalytic reformate would enter the base of the adsorption tower and leave near the top.

The molecular sieves would enter the top of the adsorption tower and slowly move down the tower by settling. A mechanical conveyor would remove the spent sieves from the base of the adsorption tower. The countercurrent flow would permit the maximum saturation of the sieves leaving the adsorption tower.

After leaving the adsorption zone the sieves would pass to a drying section where the extraneous liquid would be removed by evaporation. The saturated gases from this section would pass to a cooler and then to a separator where the condensate would be recycled to the adsorption column. The dry sieves would proceed to the reactivation section where they would be heated to 660 F and simultaneously purged with an inert gas. The hot gases from this section would also pass through a cooler and separator. The condensate would be essentially pure normal paraffins. The cooled gas would be compressed and then serve as a gas lift to return the sieves to the top of the adsorption tower. The flow of compressed gas would aid in cooling the sieves and also permit the recovery of a substantial amount of the heat required to raise the sieves to 660 F. As stated previously the use of an inert gas is required in the high temperature zones to eliminate having any explosive mixtures in the system.

Process economics. A payout period of approximately 5 years could be achieved based on preliminary economic studies. A brief outline of the economic study is presented in Table

TABLE 4. Experimental Data on Light Naphtha.

Physical Tests	Light naphtha	Effluent composite	Desorbed material
API gravity	62.7	—	72.8
Reid vapor press. psi	2.6	—	—
n_D at 68 F	1.4050	1.4077	1.3896
ASTM distillation, F			
IBP	180	—	186*
5%	190	—	194
10%	193	—	198
20%	197	—	202
30%	200	—	205
40%	204	—	208
50%	207	—	212
60%	212	—	216
70%	217	—	222
80%	225	—	229
90%	240	—	246
95%	246	—	268
EP	283	—	302
Recovery, ml	99.0	—	98.5

*Based on 50 ml of sample.

	Refractive index Values, 68 F		
Cut No.	Fraction	Run 13	Run 14
1	0-100	1.4103	1.4104
2	100-200	1.4073	1.4074
3	200-300	1.4057	1.4052
4	300-400	1.4050	—

TABLE 5. Material Recovered During Regeneration.

Sieve temp F	Run 9	Run 10	Run 11	Run 12	Run 13	Run 14
300	1.0	1.4	2.5	—	1.3	2.4
350	4.4	4.6	3.5	—	3.8	4.3
400	6.1	7.0	4.0	—	8.0	7.9
450	9.0	10.8	5.2	—	11.2	12.6
500	15.0	15.1	6.1	—	15.6	16.4
550	—	22.8	7.8	—	20.4	20.8
600	25.0	25.4	8.2	—	—	23.5
650	28.4	29.2	9.0	1.1	25.3	25.7
660*	34.7	34.7	10.1	6.8	27.5	27.0

*After one hour.

TABLE 6. Economic Justification of Proposed "Parasorb" Unit.

	Present System	Proposed System
Daily Value of Product		
189,000 gal @12c/gal	$22,680	
170,100 gal @14c/gal		$23,814
18,900 gal @8c/gal		1,512
TOTAL	$22,680	$ 25,326
Expenses-Daily		
Fuel @15c per million Btu		70
Labor-12 hours @$3.00/hour		36
Make-up Molecular Sieves 300 lb @$1.00/lb		300
Electricity @0.7c/kwh		10
Water @10c/1000 gal		3
Maintenance		60
Overhead-ins., taxes, etc		120
TOTAL		$ 635
NET VALUE OF PRODUCT	$22,680	$ 24,691
DIFFERENCE		+$ 2,011
Cost of "Parasorb" Unit*		
4500 bbl @$2.75/bbl		$1,237,500
100,000 lb Molecular Sieves @$1.00/lb		100,000
TOTAL		$1,337,500
Annual difference of product values, $2011 x 350 days annual operation		$ 703,850
Less depreciation — 8 year basis:		167,187
NET PROFIT BEFORE TAXES		$ 535,663
Taxes at 52% annual rate		278,545
ANNUAL PROFIT AFTER TAXES		$ 257,118
Percent return annually on investment		19.2%

*The Oil and Gas Journal, Vol. 54, No. 50, 135

TABLE 7. "Parasorb" Unit Heating Load.

Heating requirement	Btu per hour
Latent heat required to remove the extraneous liquid	2,080,000
Heat required to raise sieves from 200 F to 660 F	9,120,000
Heat of desorption required by normal-paraffins at 900 Btu per lb	4,110,000
Latent heat of normal-paraffins	617,000
Sensible heat of the normal paraffins	695,000
Allowance for heat loss	1,378,000
TOTAL	18,000,000

6. The basic cost of the unit was arbitrarily set at $2.75 per bbl of daily capacity. This value was an average price for catalytic reformers being constructed at the date of this study.

Labor costs were low since it should be possible to operate the "parasorb" unit in conjunction with the catalytic reformer.

The make-up of molecular sieves to the unit was estimated at 300 lb per day. The make-up would be required due to attrition of the pellets in the unit. The fines would be removed from the system by elutriation and could be repelleted on the site and reused since the adsorption capacity of the sieve powder would be unchanged.

The major utility requirement would be the heating load of the unit. As shown in Table 7 it is estimated the heating load would be approximately 18 million Btu per hr. The heat of desorption of the normal paraffins was estimated as 900 Btu per lb. This value is one-half of the heat of adsorption of water (1800 Btu per lb) as reported by Linde. No attempt was made in the study to recover major portions of the heat by exchangers therefore the values reported are admittedly high.

Proper regeneration of the sieves should permit their reuse indefinitely. A general rule should be followed that a minimum amount of olefinic materials should be present in the charge stock to avoid eventual plugging of the sieve openings due to thermal decomposition of the olefins at elevated temperatures.

Summary and Conclusions

A practical use for molecular sieves was definitely established. Their separation of normal-paraffins from other types of molecules was definite and complete until equilibrium was approached. Their high cost would be overshadowed by their capabilities if continuous adsorption units can be developed.

Future studies to develop a less rigorous regeneration technique would certainly aid in their commercial acceptance. The present sieves are easily broken and have a tendency to dust.

Possible regeneration techniques that should be investigated include the use of propane or similar low boiling material to displace higher boiling hydrocarbons from the sieves. This would permit lower regeneration temperatures since the propane vapor pressure would be greater.

Acknowledgment

The author is grateful to Dr. John B. West of Oklahoma A & M for his guidance and suggestions throughout the course of this work. I am also indebted to Continental Oil Company for the use of some of their laboratory facilities and for running octane and other tests on various samples.

References

1. Linde Air Products Company, Technical Bulletin, "Hydrocarbon Purification," Form 8603, December 1954.
2. Linde Air Products Company, Technical Bulletin, "General Information on Molecular Sieves, Types 4A and 5A," Form 8605, December 1954.

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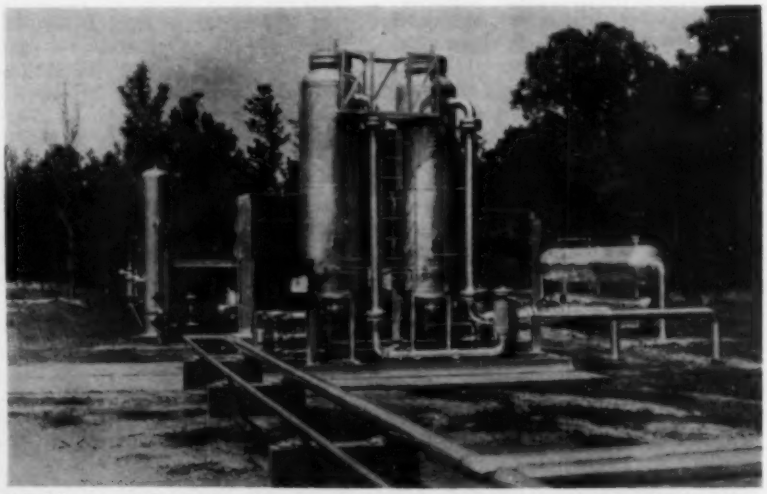
P 774.

NEW AUTOMATIC GASOLINE ADSORPTION UNIT

A new, fully automatic gasoline adsorption unit installed on a gas line near Beaumont, Texas, by Texas Gas Corporation has been working since last February and is recovering liquid hydrocarbons from lean gas at an average direct operating cost for fuel and electricity of about 15 cents per bbl of raw recovered gasoline. It has a market value of $3.20 per bbl. About half this cost is for electricity to power a five-horsepower gas pump, the remainder is for fuel gas for the adsorbent regenerative system.

The new unit, named "Dryex" and developed by Delta Tank Manufacturing Company Inc., is designed primarily for use on small, lean gas streams from wells or fields where it is uneconomical to install more conventional natural gasoline recovery equipment. The unit involves two adsorption towers, product storage tank, a heat exchanger, direct-fired gas heater, piping, gas pump, and a manifold system to switch gas from one to the other tower, also the manifold for directing regenerative gas to the towers in turn, both using three-way valves.

Costs for this unit are said to range from $800 to $1400 per bbl of daily recovery capacity, the greater the capacity the lower the incremental cost. To this about 10 percent for installation costs and auxiliary equipment must be added. At a to-the-unit-owner market price of $3.20 per bbl of product for 40 bbl per day the unit will pay out in two years or earlier, it is claimed.



This fully automatic gasoline adsorption unit has been operating since February 1957 in southeast Texas, near Beaumont, recovering hydrocarbons from lean gas that ordinarily are never recovered.

● *At Texas Butadiene and Chemical Company's Lyondell plant . . .*

Butadiene and Aviation Gasoline

go hand-in-glove

Donald M. Taylor
Gulf Coast Editor

TEXAS Butadiene and Chemical Corporation's new plant near Houston, Texas, has been described as one of the slickest plants in the petrochemical industry today.

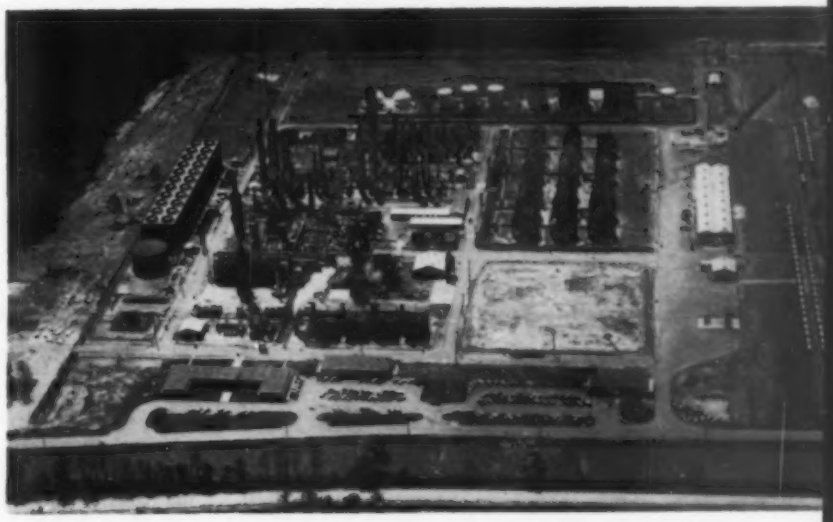
Why? There are numerous reasons, but the principal ones are the plant's excellent flexibility, its high thermal efficiency and the fact that it combines two processes that go together like ham and eggs to provide a mutual economy. One of the processes makes butadiene by dehydrogenating butane; the other makes alkylate the basic blending stock for aviation gasoline.

While there is some disparity in the end products, the two units interchange by-products. For instance, the primary feed stock of the alkylation unit is the butylene by-product from the butadiene plant. On the other hand, the debutanizers in the alkylation plant furnish a portion of the primary feed stock for the butadiene plant. This makes the two units, which are individually self sufficient, as closely allied as any in the chemical industry. They gobble up copious quantities of butanes and jointly produce excellent yields.

As a matter of fact, this plant is the world's largest purchaser of LPG for petrochemical manufacturing. All told, it consumes about 360,000 gal of commercial grade butane per day plus 180,000 gal of isobutane and 65,000 gal of isopentane. The latter is used to blend the final aviation gasoline product. The plant was designed to produce 64,800 tons per yr of commercial butadiene (made into rubber this is equal to 6 million automobile tires) and about 2½ million bbl of blended aviation gasoline per year.

And, the plant operation can be altered to produce 86,000 tons per yr of butadiene, should market demand for this product or aviation gasoline so dictate.

Aside from this petrochemical affinity, there's another factor that strongly affects the economy of the two processes, and that's the thermal efficiency. You have only to take a look about the plant to realize that the designers devoted a great deal of time chasing Btu's around a flow sheet. There are 144 heat exchangers of varying size,



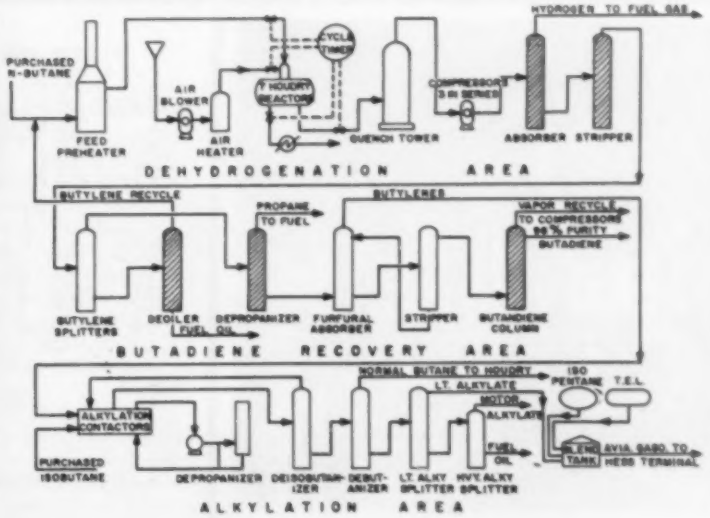
Texas Butadiene and Chemical Company's new plant on the Houston Ship Channel, recently onstream, is the world's first post-war butadiene manufacturing installation.

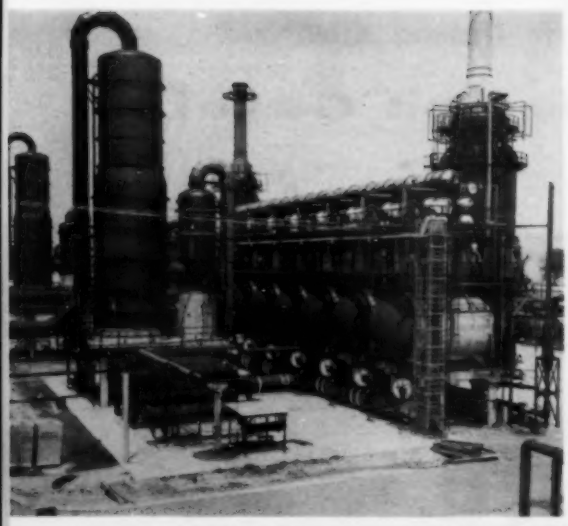
and they greatly lessen the overall fuel requirements of the plant through utilization of waste heat. While there's no way of comparing the thermal efficiency of this plant with similar ones, it is readily apparent that its ranking would be near the top. The exchangers total almost 2,000,000 sq ft of tube surfaces — this tallies up to approximately 375 miles of tubes.

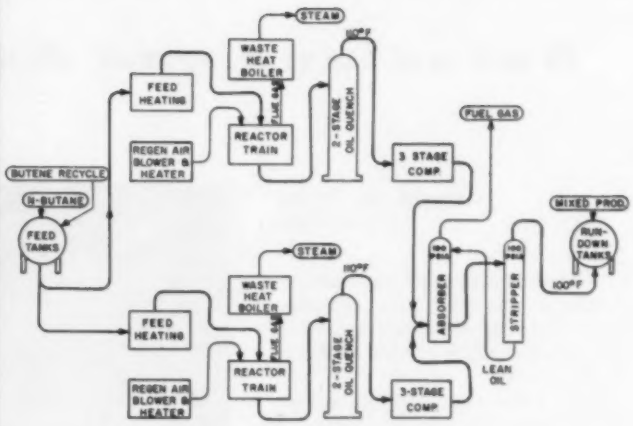
TB&C (the company name as referred to by employees) is the world's third butadiene plant using the Houdry dehydrogenation process. However, one of the two previous plants has been dismantled, thus making this plant one of two now operating, and the first completed by private industry since World War II.

The plant is divided into three basic

Simplified process flow diagram of the Lyondell Plant. As is evident, there are three distinct process areas — Butane Dehydrogenation; Butadiene Recovery, and Alkylation. The crosshatched items indicate two units operating in parallel.







BUTANE DEHYDROGENATION . . .

Photograph and flow diagram of the dehydrogenation units. In the picture, the equipment on the right are the reactors, the product from which is quenched in the towers at the left to prevent polymerization and other undesirable reactions. The catalytic dehydrogenation process is licensed by Houdry Process Corporation.

process areas, as shown in Fig. 2. Raw materials are normal butane, isobutane, and isopentane. This is the plant operation, in a nutshell: The normal butane is dehydrogenated to yield butadiene and butylenes. The butadiene is recovered and purified for sale. About half the butylene is alkylated with isobutane and isopentane added to make avgas. The other half of the butylene is recycled to the dehydrogenation unit to make more butadiene.

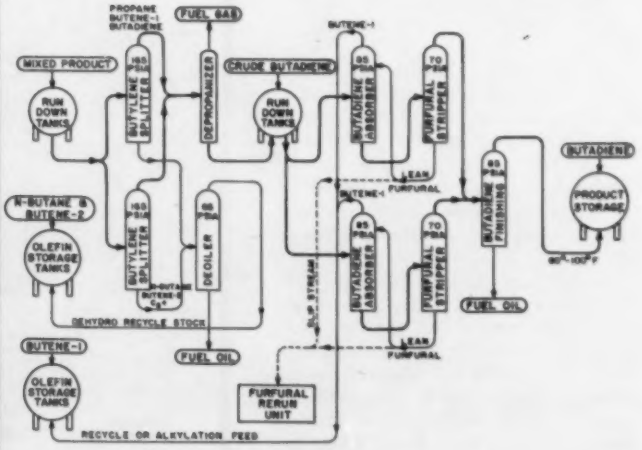
Butane Dehydrogenation

The feed to the dehydrogenation area is commercial normal butane, as mentioned. This feed is combined with a butane-butylene recycle stream. The total feed is then preheated and fed to one of two Houdry fixed bed catalytic dehydrogenation units and reacted at a temperature in the range of 1050 to 1150 F and under a vacuum of about 12 lb (three pounds absolute pressure).

The dehydrogenation process is cyclic. Each of the plant's two units has seven reactors. At any one time, reaction is taking place in three of the seven reactors; in three other reactors, the catalyst is being regenerated by hot air to turn off carbon deposits and the seventh reactor is being prepared for one of the above steps. The sequence and timing of these steps is dictated by a master electric "brain" which can change one process operation every 1.4 seconds and which actuates 50 large (up to 30-in. ID) hydraulically-operated valves. The axial flow compressors

BUTADIENE RECOVERY AREA . . .

Here, butadiene and by-products are separated from the dehydrogenation reactor products. There are 29 factionating columns in the plant — two of them 200 ft high. Heart of the operation is the extractive distillation towers that use furfural to aid in isolation of butadiene. This process is licensed by Phillips Petroleum Company.



and air heaters used to deliver and heat the air needed for catalyst regeneration are the largest such units ever built for hydrocarbon process use. The hot reacted effluent gases are immediately quenched to prevent undesirable side reactions, then compressed to about 160 psi, and processed through an absorption-stripper cycle where various unusable by-products are removed.

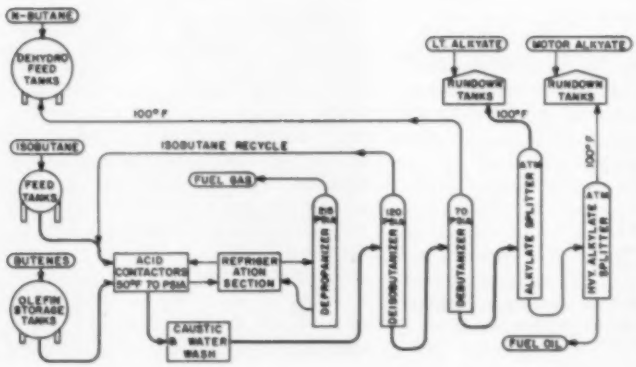
Butadiene Recovery

The product from the dehydrogenation area is fed to the butadiene recovery area. The first step is the separation of butane and heavier hydrocarbons from the butadiene and lighter hydrocarbons by conventional distillation. The butadiene and lighter fraction taken overhead is depropanized and processed through furfural extractive distillation units where the butadiene is separated from the lighter components. After the butadiene is stripped from the furfural, it is superfractionated to make a rubber specification grade butadiene not less than 98 percent purity. Part or all of the unreacted butanes and butylenes may be returned as recycle to the Houdry unit, or part may be sent to the alkylation unit. The choice that may be exercised at this point gives this plant its unique flexibility. TB&C has the only butadiene plant in existence with this built-in versatility.

Alkylation

This area is a conventional sulfuric acid alkylation plant, using the effluent refrigeration process. There are four parallel contactors in which isobutane and butylene are reacted at 40 to 50 F and 55 psig. The total alkylate stream is separated into an internal isobutane recycle, normal butane that is returned to the dehydrogenation area, and into two alkylate product streams. Heavy alkylate is sold as a motor fuel blending component. The 335 F EP light alkylate is blended with isopentane, or another suitable stock, leaded, and marketed as 115/145 avgas.

Refrigeration load is 2500 tons. A cost-cutting and operations-simplifying feature is the combination compressor suction dry drum and refrigerant flash drum. And, the liquid refrigerant stream cools the compressor anti-surge gas by direct contact and heat transfer, thus the system can be put on recycle for indefinite periods.



ALKYLATION AREA . . .

The effluent refrigeration alkylation contactors in the foreground of the photograph take butylene from the towers in the background, react them with isobutane to make avgas blending stock. Capacity is roughly 100-million gallons per year of alkylate. Stratford Engineering Corporation licensed the effluent refrigeration process, and Texaco Development Corporation licensed the sulfuric acid alkylation process.

Flexibility

For the first time in history, a process plant has been put together to make butadiene and aviation gasoline directly from butane hydrocarbons so that what is not used up for butadiene gets used in avgas with considerable flexibility in choice of the end product ratio. By exactly similar integration, and with comparatively minor process changes and equipment additions, this same plant could make the other two key synthetic rubber raw materials, isobuytlene or isoprene, along with avgas if the pentane hydrocarbons are added to the raw material list.

The recycle stream to the dehydrogenation unit, is primarily, butane and butene-2. Butene-1, taken overhead from the butadiene absorber, is sent to storage for use as dehydrogenation unit recycle or alkylation feed.

As mentioned, butadiene production can be varied from 64,800 to 86,000 tons per yr at design feed capacity, depending upon market dictates.

Storage

To store the quantity necessary of raw materials above ground in standard pressure vessels would be extremely expensive; so, TB&C has resorted to underground storage wells located in a salt dome near Mont Belvieu, Texas. This dome, 14 miles northeast of the plant, will eventually be the site of the world's largest underground storage. The total storage capacity to be developed there by Texas Butadiene and others will be approximately 210 million gal. Texas Butadiene's portion of this storage will be 65 million gal.

Plant site storage includes 139,000 bbl of spheres for product butadiene, crude butadiene, butenes, isobutane, and normal butane. Storage for avgas rundown, blending, and product storage totals 90,000 bbl, 10,000 bbl of spheroid tanks; 60,000 bbl of floating roof storage; and 20,000 bbl of cone roof tankage.

The butadiene recovery area control room is one of three control rooms at the TB&C plant. The others serve, of course, the dehydrogenation and fractionation sections of the plant.

Instrumentation and Control

The company desired the plant to be one of the most modern from the standpoint of instrumentation and automation. Such instruments as ultraviolet, infra-red and vapor fractometer analyzers were installed in the plant as onstream control equipment, as shown in Table 1:

TABLE 1. Onstream Hydrocarbon Analyzers.

Type	Monitored Component	Function	Location
Ultra-violet	Butadiene	Controller	11th tray north butylene splitter
Ultra-violet	Butadiene	Controller	11th tray south butylene splitter
Ultra-violet	Butadiene	Recorder	Deoiler overhead & depropanizer overhead
Ultra-violet	Butadiene	Recorder	North and south butadiene absorber overhead
Ultra-violet	Butadiene	Controller	5th tray butadiene finishing column
Infra-red	Butene-1	Controller	25th tray north butadiene absorber
Infra-red	Butene-1	Controller	25th tray south butadiene absorber
Infra-red	Acetylenes	Controller	79th tray butadiene finishing column
Chromatog	Butane	Recorder	89th tray south butylene splitter

Maximum use was made of electronic and pneumatic control, and as a result, only 17 men per shift operate the entire plant. One of the most interesting control systems is the automatic unit that is used for operation of seven dehydrogenation reactors.

Each of the reactors operates on a 20-minute cycle-reaction, during which time coke is deposited on the chrome oxide-alumina catalyst, purge and evacuation, regeneration with air, purge and evacuation, followed again by a reaction period. At any given time there are three reactors onstream, three on regeneration, and one on purge, evacuation, or valve change.

Each of the reactors has seven gate valves controlling the flow of feed, products, vacuum purge, combustion air, flue gas, etc. There are a total of 98 hydraulically controlled valves comprising the entire system.

Automatically controlled by a cycle timer, the power requirements—at a central power unit—are only 30 hp. An electrical control system would have required 400-500 connected horsepower for valves ranging from 4 to 30-in. diameter. The valves are operated by small hydraulic cylinders which in turn are operated by solenoid valves at the central control panels.

There are seven panels, one for each reactor, that control seven valves each. In addition, each central panel has a unit that will open the reactor by-pass valve should an emergency occur.

Operating times for the gate valves are as low as one second for the smaller units to four seconds for the larger valves.

Four-way solenoid valves control the flow of hydraulic fluid to the control valves. Power requirements are minimized by the use of ten 10-gal hydropneumatic accumulators that discharge about 20 gal of oil every three minutes, the peak circuit demand.

Several advantages are cited for the system. Control wiring and size of the installation were reduced to about one-tenth of that of an electrical system. Also, rate of valve travel can be varied at any point in the stroke, and slow stops and starts that eliminate "slamming" are gained by simple external valving. And, the actual operating forces required to move the valve gate can be varied by simply adjusting the relief valve.

This system was designed and built by Rivett, Inc., of Boston, Massachusetts.

Construction Highlights

On August 23, 1955, TB&C acquired its present site of 400 acres located on the San Jacinto River five miles north of Channelview and approximately 20 airline miles from the center of Houston. Three days after the purchase, Fluor Corporation's bulldozers first broke ground and the plant construction commenced. During the next year and a half over 4000 truck loads of concrete were poured; 175 process pumps, 29 fractionating towers, 144 heat exchangers, 129 pressure vessels, 50 storage tanks, and over 75 lineal miles of pipe were installed. No major setbacks in construction were experienced and the plant was completed on February 1, 1957.

Company Organization

On July 2, 1954, Texas Butadiene & Chemical Corporation was incorporated in the state of Delaware and became one of the newest members of the fast developing petrochemical industry. Prior to this date, the company was only an idea of Dr. Robert L. Purvin, Purvin & Gertz, Incorporated, Dallas, Texas. Dr. Purvin and the Fluor Corporation, Los Angeles, who became the sole engineering-construction contractor, worked out the process design, preliminary engineering and economics of the process. After financing was arranged, further process assistance was obtained from the Houdry Process Corporation, Texaco Development Corporation, Stratford Engineering Company, and Phillips Petroleum Company, all of whom eventually became licensors of processes in the Channelview Plant of Texas Butadiene.

The plant is the first in the synthetic rubber industry to be financed totally from private capital. At the present time Godfrey L. Cabot, Inc. of Boston, Massachusetts and Carl M. Loeb, Rhoades & Company of New York are the principal stockholders. ★ ★ ★

HOW VICKERS BOOSTED Package TCC Capacity 50 Percent

Modification of hot catalyst storage bin into a third kiln and revision of catalyst circulation system done at low cost — normal turnaround period used to make tie-ins

Stephen Valentine III
Socony Mobil Oil Company
T. Ben Arnold
Vickers Petroleum Company

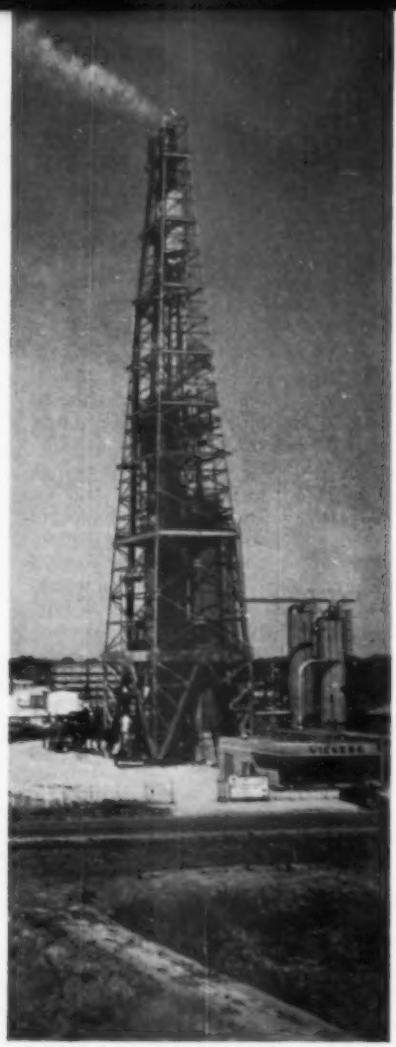


FIG. 1. Vickers' TCC Unit shortly after initial startup in February 1953.

VICKERS Petroleum Company recently increased the capacity of their package Thermofor Catalytic Cracking Unit in Potwin, Kansas, by 50 percent — at a total cost of about 10 percent of the initial investment for the complete TCC (catalyst and oil side) installation. The full details of the project were disclosed in a paper — summarized here by its authors — presented at the Regional Meeting of the Western Petroleum Refiners Association, Wichita, Kansas, June 20-21, 1957.

FIG. 2. Expanded TCC Unit in May 1957. Note the "outboard" catalyst storage hopper that was added.

Unit Design

The Vickers TCC Unit is a "package" unit — all of the process vessels were shop fabricated, including the reactor and twin kilns, plus the synthetic crude (products) tower and tar separator used in conjunction with the TCC unit. The TCC vessels were mounted inside a derrick structure, which permitted installation without the use of rigging equipment.

Catalyst flow in the original unit is shown in Fig. 3. The catalyst flows in a compact stream from the separator at the top of the unit down through a seal leg into the 11 ft 5 in. diameter reactor, where it contacts oil vapors and liquid fuel. Cracking takes place in concurrent flow with the catalyst. The vapors are disengaged from the reactor and the catalyst gravitates into two identical, 12 ft diameter kilns for regeneration. It then passes through the tube side of tube-in-shell coolers and drops into the lift pot. There it is picked up by a moving air stream and flows upward into the separator to resume the flow cycle.

The initial investment for the installation — feed preparation, TCC, fractionation, and gas plant, was about $2.1 million, of which about a third was for the TCC unit only.

Initial TCC Operations

Crude capacity at the Potwin refinery was upped to 10,000 bbl per day at the time the TCC unit initially went onstream in February 1953. The cracker was designed to process 4000 bbl per day of fresh feed at a 0.6 recycle ratio — equivalent to 6400 bbl per day total reactor charge. Kiln capacity was rated at 3400 lb per hr, with a catalyst circulation rate of 165 tons per hr. De-

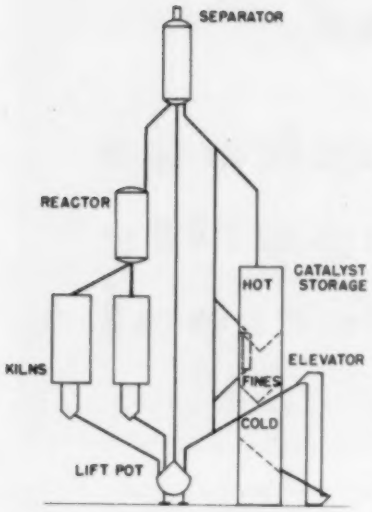


FIG. 3. Arrangement of catalyst section before modification.

sign debutanized catalytic gasoline production was 2200 bbl per day.

By September 1955, the capacity of this unit had been substantially increased by normal refinements and greater operating knowledge. Refinery crude run was up to 13,000 bbl per day; fresh feed to the cracker was about 6000 bbl per day with about 1500 bbl per day of recycle. This represents a 17 percent increase in total feed capacity. The coke burning capacity had been increased to 4500 lb per hr — 132 percent of original design — on 190 tons per hr catalyst circulation. Debutanized catalytic gasoline production was up 22 percent to over 2700 bbl per day.

More Carbon Burning Capacity Required

It became apparent that 4500 lb per hr was the maximum coke loading for the twin kilns, thus limiting further increase in cracking capacity. However, the reactor, with three levels of disengaging channels, had a capacity of 10,000 bbl per day. Additional capacity was therefore possible if a third kiln could be installed parallel to the existing kilns and catalyst circulation capacity could be increased to 290 tons per hr.

Catalyst Storage Hopper Converted to Kiln

Since the existing catalyst storage vessel (see Fig. 3 and 4) was adjacent to the existing kilns and to the lift pot, it was converted into a kiln. The diameter of the vessel was identical to that of the existing kilns, enabling installation of a full size kiln and catalyst cooler within the shell.

In order to make the conversion while the unit was still operating, it was necessary to first build a new hot catalyst storage hopper. The new hopper, erected between the structure and the control room as shown in Fig. 5, was skirt-supported, permitting the volume beneath the bottom head of the hot bin to be used for additional fresh catalyst storage. The hot bin had to be tall, of course, in order to insure gravity flow of catalyst to the lift pot.

Tie-ins to the new bin were made during a scheduled turnaround. It was then possible to prepare the old hot bin for use as a kiln. The top head was removed, inner cones cut away, and a large opening cut through the shell and suitably reinforced to provide access to the new cooler.

The cone bottom of the old hot bin was relocated to form the bottom head of the new kiln. Internal insulation was applied and support brackets hung. Assembly of the kiln internals followed, from the bottom up, by lowering the components from above.

Fig. 6 shows the relationship of the new kiln to the other vessels of the unit along with the assembly of the kiln internals. From the bottom up, the parts include the catalyst cooler, the catalyst drawoff plate and pipes. The flue gas collector pipes were attached to the drawoff plate, and the flue gas disengaging channels suspended over the pipes from their support brackets. The catalyst and air distributor assembly was located as a unit, followed by the top head of the kiln.

A new turbine driven combustion air blower was installed adjacent to the existing combination blower to utilize existing surface condenser equipment. This blower was piped directly to the new kiln without an air line burner. A 24-in. diameter combination flue gas stack was installed with connections from the top and bottom plenum chambers of the kiln.

All of this work, hot bin, kiln, kiln auxiliaries, plus the installation of a new gas compressor was done by refinery maintenance forces augmented only by two welders who were expressly hired for the expansion program. No additional downtime had been required as the catalyst circulation system tie-ins to the new hot bin were made during a scheduled turnaround.

Other Catalyst Side Modifications

Certain parts of the catalyst and oil circulation systems required modification to accommodate the increased catalyst and oil rates. On the catalyst side, the reactor seal leg was the only line that needed to be replaced by one of larger diameter. All other catalyst lines, lift pipe and catalyst valves were adequate for the increased circulation. Some new catalyst piping was required — a line had to be run between the reactor catalyst outlet and the new kiln, and piping between the new cooler and the lift pot, including catalyst meter box and lift pot seal leg, was needed. Some modifications to the lift pot were necessary to accommodate the latter. Fig. 7 illustrates these revisions to the catalyst circulation system, and shows schematically the modified arrangement of the unit.

These cat side modifications could only be made while the unit was down. However, practically all of the new pipe sections — seal leg, meter box, piping from reactor to kiln — could be shop fabricated. Actual field work at shut-down was limited to revising the lift pot and modifying certain sections of the catalyst elutriation and makeup system. Tie-ins, aside from installation of the shop fabricated piping, were made between the new cooler and the steam drum on the thermosyphon system, and a cooling air connection to the bottom kiln plenum was made from the existing cooling air fan for control of bottom stack temperatures.

Oil Side Revisions

Changes included installation of a new intermediate reflux system for the

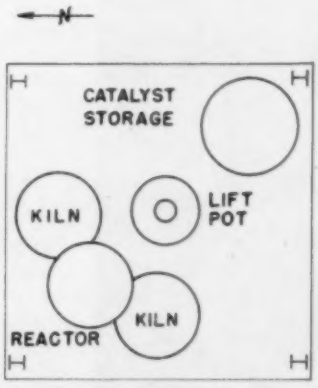


FIG. 4. Plan of catalyst section prior to modification.

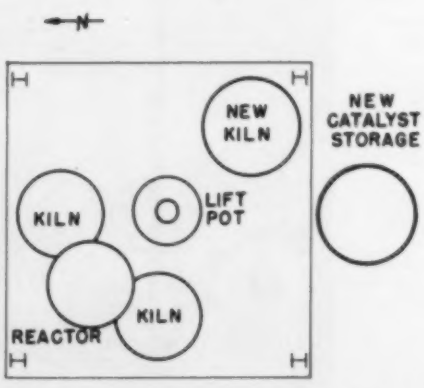


FIG. 5. Location of new catalyst storage vessel.

syn tower and additional syn tower overhead condenser surface. While the latter was not directly applicable to the expansion program, both modifications have appreciably reduced the pressure drop in the fractionation system. No modifications were made to the feed preparation section.

The turnaround for final tie-ins occurred last November. This was a normally scheduled turnaround, and all tie-in work was accomplished within the scheduled period. Following this, Vickers brought the revised unit back onstream, again with no operational difficulties. Catalyst circulation has reached 300 tons per hr and all components have functioned satisfactorily.

Some further work is required in the feed preparation section as the main charge furnace currently limits the recycle rate to the reactor. This bottleneck will be eliminated either by the use of additional exchangers or by installation of a small recycle heater.

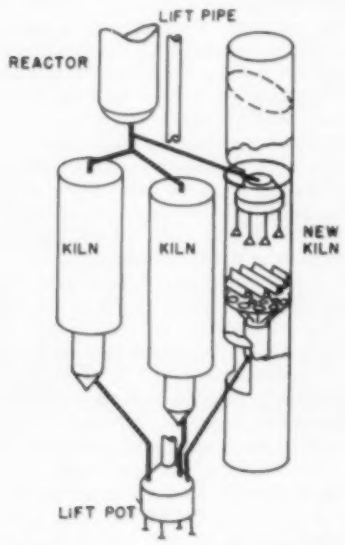


FIG. 6. Arrangement of new kiln within structure.

Predicted Operations

With their expanded unit, Vickers will have the capacity to charge over 7000 bbl per day of fresh feed (10,000 bbl per day total feed with 1200-2000 bbl per day liquid) to the reactor which will be obtained from 18,000 bbl per day crude oil charge. This is an increase in fresh feed of 75 percent over the original design. From this charge, they can expect to produce 3200 to 3500 bbl per day of debutanized TCC gasoline, up to 60 percent more gasoline than design; 30 percent more than operations prior to the modification. Their rated coke burning capacity is now 6750 lb carbon per hour or 50 percent over recent operations. Crude charge capacity will be 18,000 bbl per day. Current coke burning capacity is 100 percent greater than original design.

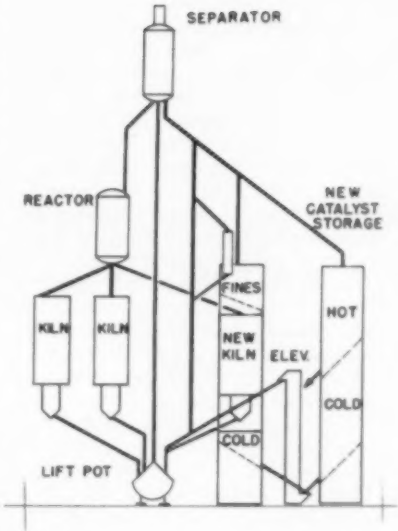


FIG. 7. New arrangement of catalyst section.

This sizable expansion was accomplished at moderate cost and little loss of operating revenue, since most of the work could be done with the unit onstream. The package concept of the Vickers TCC was the salient factor in prevention of a prolonged shut-down or series of shut-downs that otherwise would have been required for a cat cracker expansion of such magnitude.

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How to Face a *HURRICANE*

This is a report on how Continental Oil Company's large Lake Charles refinery prepared for and rode out one of the country's most destructive hurricanes. Even more dramatic than the manner in which the refinery equipment survived the storm is the human story . . . how a major industrial organization pitched in with local authorities and disaster organizations to alleviate human hardship.

The story is told in refinery manager J. M. Jones' own words — just as he reported the occurrences before, during, and after to Continental's headquarters in Houston, Texas.

J. M. Jones,
Manager
Continental Oil Company Refinery
Lake Charles, Louisiana

ON Tuesday, June 25, 1957, the Weather Bureau advised that U. S. Navy reconnaissance planes had established that Hurricane Audrey was located approximately 450 miles south of Lake Charles and moving in a northerly direction at about 7 mph. This did not cause much concern because as a rule hurricanes do not hold to a straight course. However, by Wednesday morning it was evident that the Lake Charles area was in danger. The 10 a.m. advisory indicated the storm was still holding a northerly course along Longitude 93.5 which placed Lake Charles in its path. Through the great cooperation of our Lake Charles CATC office, we were kept advised of reports from our offshore rigs. This was extremely helpful to us because it gave us detailed information about the intensity of the story and this coupled with the Weather Bureau advisories, permitted us to closely estimate the time high winds would strike Lake Charles.

The 4 p.m. advisory on Wednesday indicated the hurricane was still holding a northerly course with winds up to 105 mph near its center and was centered approximately 300 miles due south of Lake Charles, moving at about 10 mph. At this time a meeting of all department heads and operating foremen was held to plan our course of action. It was estimated that should the hurricane hold its present course and speed, high winds would strike Lake Charles by mid-morning Thursday. On the off-chance that it would change its

course at this late time, it was decided to hold another meeting of the group at 10 p.m., at which time another weather advisory was to be broadcast.

The 10 p.m. advisory indicated the hurricane was centered 235 miles due south of Lake Charles, moving at a speed of 10 mph, and still holding a course along Longitude 93.5. CATC had reported 105 mph winds with gusts exceeding 150 mph and based on these reports, it was estimated we would be hit hard by 8 a.m. Thursday. Each operating foreman gave his estimate of the minimum time he would need to safely circulate his unit down. The Catalytic Reforming Unit, requiring 8 to 10 hours, was started down immediately. It was decided to await an intermediate Weather Bureau bulletin which was to be broadcast at 2 a.m. Thursday, before starting the other units down.

Our plant disaster control organization was activated at 10 p.m. Wednesday. The 2 a.m. bulletin indicated no change in the course or intensity of the storm, except that it had picked up speed moving at 20 mph. The order was then given to cut fires, secure all units and hold them on circulation. This was accomplished by 8 a.m.

By 7 a.m. Thursday, the center of the storm hit the coast and by 10 a.m., the wind had reached a velocity of 105 mph at Lake Charles. Our disaster control organization, which had been activated at 10 p.m. on Wednesday, was functioning and things within the refinery were completely under control. Our ambulance had been working since early in the morning, moving the bed-ridden residents of the Westlake area to the high school shelter. At the height of the first phase of the storm, the power failed in the Westlake area and several hundred refugees found themselves without water. Civil Defense notified us and our employees rounded up all the water containers, drums and cans available and we kept the shelter supplied with water.

During this time the power failed in Lake Charles and all local radio and TV stations went off the air. Telephone communications became extremely unreliable and during long periods failed completely. Our only means of communication during the rest of the storm was by means of messengers and our Mutual Aid Association short wave radio. The messenger system organized by our disaster control committee functioned well.

However, our docks were completely cut off by high water and telephone communication was extremely spotty. The seas were so high, our small outboard driven boat could not navigate. The dock crew took refuge on the S. S. Ponca City which had finished loading and rode out the storm undamaged. Several of our offshore work boats and other crafts were given refuge at our docks and suffered no damage. During this first phase of the storm, two concrete silos, 90 ft high and 24 ft in diameter, on the new Coker job were blown down. Otherwise, the plant proper suffered only minor damage.

During this first phase of the storm, all automotive equipment and personnel which could be spared were made available to Civil Defense in the Westlake area.

The eye passed over Lake Charles at about 11 a.m. and during the next hour, a relative calm prevailed. A little after noon, the backlash hit with winds up to 100 mph and torrential rains. Appeals began to come in for gasoline to man Civil Defense and other emergency equipment. These requests were freely complied with. A total of 6000 gal was furnished during the emergency. In the midst of the backlash, we received an appeal to get gasoline to the Gibbstown Ferry on the Intercoastal Canal where amphibious boats and other rescue craft in the Creole area were out of fuel. Our local Commission Agent furnished a truck and driver and the gasoline was delivered under the most trying conditions.

After 1 p.m. we suffered a power failure in the plant caused by tree limbs being carried across our high lines and the extreme wind velocity causing the lines to sag and slap together. This shut three of our water wells down and had we been attempting to operate our units at the time, we would have faced a most serious situation considering the intensity of the storm.

By 4 p.m. on Thursday, the wind velocity had reduced to about 45 mph with gusts up to 60 mph. The 4 p.m. weather advisory indicated the storm was on the wane in this area with little likelihood of retracing its course and based on that information instructions were issued to resume operations. By 6 a.m. on Friday, June 28, all units were back onstream with the exception of No. 1 Catalytic Cracking Unit and the Catalytic Polymerization Unit, both of which came onstream about mid-afternoon. Total damage to the plant, excluding the Coke silos, is estimated to be no more than $9000. Our personnel suffered no injuries except minor first aid cases.

By Friday morning the scope of the disaster at Cameron, Grand Chenier, Little Chenier, Pecan Island, Creole and all areas south of the Intercoastal Canal became evident. Civil Defense and the Red Cross made an appeal for boats to take them into the stricken area for rescue and evacuation work. Many of our employees responded and were released for this work.

At 5 a.m. on Friday our ambulance was placed in service at the City Docks where sick and injured people were being brought by boat from the stricken areas. Our plant nurse met the Continental workboat, LaFourche, at the City Docks where it discharged the first load of survivors. She worked with the medical authorities, administering first aid and giving oxygen when necessary. She and many other employees practically lived at the dock through Saturday and Sunday. We furnished first aid kits, stretchers and other medical supplies, holding back in the refinery only enough for local emergency use.

Our limited communication facilities consisting of a Walkie-Talkie radio and public address speaker system were turned over to the various agencies working at the City Docks.

Two refinery employees were dispatched with emergency first aid supplies to travel with the LaFourche with instructions to do what was necessary and to communicate with the refinery by short wave on anticipated needs. Numerous requests for provisions and supplies were made and taken care of.

On Saturday, the dead began arriving at the City Docks where a morgue was set up in one of the large sheds. Identification of the bodies was extremely difficult and in most cases not possible, which resulted in the bodies being kept much too long in the intense heat. Our nurse organized several of our employees and other volunteers at the City Docks into a group which made 2500 gauze face masks to be worn by people trying to identify the dead. We furnished ammonia from our refinery stocks to be used with the masks. We also furnished a substantial amount of lime.

Our vacuum truck was sent down to Cameron Sunday night and has been used since that time in the more critical preliminary phases of cleanup work. On July 4, a group of 100 of our employees went to Cameron and worked their holiday, helping the cleanup crews. Club Continental, an employee organization, donated $1000 to Cameron relief instead of holding a picnic which they usually have on July 4.

I cannot say too much for the manner in which our employees conducted themselves during and subsequent to the storm. Morale was high, everyone kept his head and did his job well during the storm. I have never witnessed a better demonstration of unselfish personal effort to pitch in and help the community than was shown by our people. We have every reason to be very proud of them. ★ ★ ★

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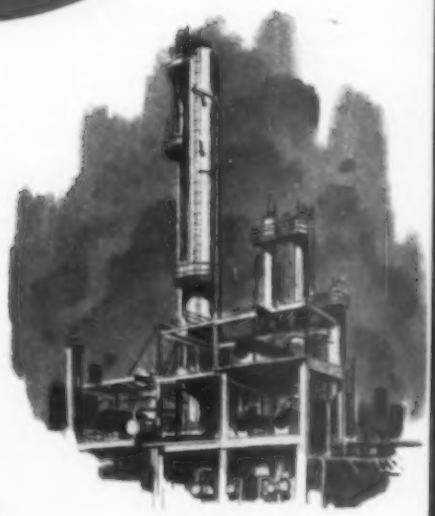

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Hydrogen Peroxide— Petrochemical Newcomer

Part 1 | *Applications of H_2O_2; Established Manufacturing Processes*

Peter W. Sherwood
Chemical Engineer, White Plains, New York

EARLY estimates place 1956 production of hydrogen peroxide in the United States near 50 million lb. This represents a 67 percent increase in output since 1953 when hydrogen peroxide was turned out at the rate of approximately 30 million lb per year.

Until early 1953, output of hydrogen peroxide had experienced a gradual and steady climb, which began in the mid-twenties and was interrupted by a drop during only two short periods (both in the 1930's). Output in 1940 was 6.5 million lb (basis: 100 percent H_2O_2). It climbed to 22 million lb in 1950, 24 million in 1951, 27 million in 1952 and 30 million in 1953.

Subsequent figures can only be estimated. 1954 output has been guessed at 34 million lb and 1955 production at 42 million lb. In early 1956, production rate was guesstimated at 43 million lb[1] and there is evidence that the year's final production figures will be close to 50 million lb (official production data started to become available in March 1956).

Keeping up with this rise in production demand, U. S. plant capacity for hydrogen peroxide has been boosted from 23 million lb at the start of 1951 to 58 million lb in the beginning of 1956 — an increase of 152 percent.

Market-wise the important development of the last few years has been a definite shift in the distribution pattern, a trend which yet must make its full impact felt. For one thing, there is growing interest in hydrogen peroxide for military use. But even in the civilian market, hydrogen peroxide is finding new outlets. These may some day overshadow sales for bleaching purposes which are today predominant.

Of paramount interest are uses for hydrogen peroxide in chemical syntheses, just recently commercialized. A plant employing a wholly new route to production of glycerine from propylene was taken on stream in 1956 at Shell Chemical Company's Norco, Louisiana, installation. In this process, allyl alcohol is reacted with hydrogen peroxide to yield glycerine.

$$CH_2 = CH - CH_2OH + H_2O_2 \rightarrow HOCH_2 - CH(OH) - CH_2OH \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Hydrogen peroxide for this process is also manufactured at Norco, in a 30 million lb per year plant, constructed during 1956.

Epoxidation of fats and oils (to yield, ultimately, plasticizers) has been another fruitful chemical outlet for hydrogen peroxide in recent years. This market is, however, threatened today by a newly introduced process in which peracetic acid serves in lieu of hydrogen peroxide as epoxidizing agent. The competitive process, though still in pilot plant stage (it is being developed by Carbide and Carbon Chemicals Company) offers a potential cost advantage if technical difficulties and hazards can be overcome.

Other chemical uses for hydrogen peroxide include above all:

(a) Hydroxylation of lecithin to yield an emulsifier of importance in the production of candies, bakery products, etc.

(b) Various oxidation reactions, among them oxidation of glucose to gluconic acid (a reaction which serves to retain better taste quality in dried eggs). Also of interest is the oxidation of vat dyes from their soluble leuco state in which they are applied to the fiber. It is claimed that the use of hydrogen peroxide for the final oxidation step brings about cleaner and brighter shades.[2]

It must be pointed out that the price of hydrogen peroxide per equivalent of oxidizing power is quite high. Thus, Satterfield[4] calculates a cost of $20 per lb atom available oxygen, compared with $18 in the case of chromic trioxide and about $1.00 per lb atom chlorine in chlorine. This fact confines the oxidizing use of hydrogen peroxide to applications where the unit value of product is relatively high and where other considerations (product quality, objection to byproducts from other oxidizing agents) are overriding considerations.

(c) Polymerization catalyst. Like other peroxides, hydrogen peroxide is an effective catalyst for a wide range of polymerization reactions.

While chemical syntheses promise to provide the large (civilian) hydrogen peroxide market boost of the next few years, the principal outlet continues to be in various bleaching operations. Here, too, advantage is taken of the strong oxidizing potential of hydrogen peroxide which yields water as byproduct.

The continuing importance of bleaching applications in the hydrogen peroxide sales picture may be gaged by a look at the estimated (civilian) distribution pattern in 1953 and in late 1956.[6]

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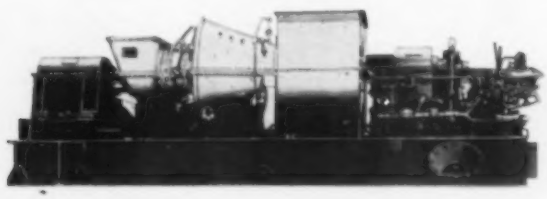

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TABLE 1 — Distribution Pattern for Hydrogen Peroxide.

	1953[7]	1956[8]
Textiles (bleaching and oxidizing)	65%	39%
Pulp and paper	15	18
Chemical manufacturing	15	21
Miscellaneous	5	22 (about ½ for foam rubber)

Preeminence of textile applications is evident. It is reported that practically all white and colored shirts, dresses, underwear, handkerchiefs, towels, and bed linens are produced from material which has been bleached with peroxide.[2] Especially in the case of wool and silk, the use of hydrogen peroxide is imperative, as other bleaching agents attack and degrade the fiber. But pronounced advantage exists also in the use of hydrogen peroxide for bleaching cotton and most of the synthetic fibers.

Use of hydrogen peroxide for bleaching pulp and paper is on the uptrend. Here, peroxide bleaching permits production of higher grade paper from groundwood pulp that would otherwise be possible. This material was previously confined to low grade uses — newsprint, boxboard filler, etc. — but since the introduction of hydrogen peroxide bleaching, cheap groundwood pump may also be mixed into pulps used for books, magazines, envelopes, etc.

Hydrogen peroxide has also made inroads into the bleaching of soda and sulfite pulps, particularly in the production of specialty papers of extra brightness and color permanence. In this application, the better product quality justifies the incremental cost of peroxide above that of hypochlorites — the bleaching agent which is more commonly used for sulfite pulps.

Competition to hydrogen peroxide even in this specialty field is provided by chlorine dioxide, a very effective bleaching agent which has, however, a disadvantage in that it is poisonous, corrosive and also fairly costly.

In the catch-all category of "miscellaneous" uses for hydrogen peroxide, we find above all its use as a source of gaseous oxygen. The fact that one volume liquid hydrogen peroxide may be decomposed readily to yield about 500 volumes oxygen (plus steam generated by the heat of reaction) is used to good advantage in the production of foam rubbers. Here, hydrogen peroxide is incorporated into the latex batter (sometimes with an added decomposition catalyst, such as ethylene diamine). The batter is then allowed to expand until it fills the mold after which time it is gelled and vulcanized.

There has been some experimental extension of such foaming techniques to the production of porous structural materials such as lightweight wallboard and concrete blocks, using hydrogen peroxide as gas source.

In the field of "miscellaneous" applications for hydrogen peroxide, mention must further be made of its use as a mild antiseptic which permits bactericidal action in open wounds and is also drawn upon to prevent spoilage of such products as gelatin, whey, and starch.

Hydrogen peroxide offers potential value as an "antichlor," i.e. for the removal, by oxidation, of chlorides which are introduced in previous treatment and are difficult to remove by other means (a situation which occurs, e.g., in hypochlorite-treated shellac). The compound has also shown some promise in the formation of corrosion-resistant oxide coatings on metal surfaces and in achieving various other improvements on metals (e.g., greater brightness, more durable finish, etc.).

Various photographic printing processes call for the use of hydrogen peroxide. It serves, for instance, as hypo eliminator, as an ingredient in blueprint developers, etc.

These, then, are the civilian markets to which the hydrogen peroxide manufacturers look above all: The established outlets in the textiles and paper industries, and also, the new horizons which are appearing in a variety of fields, especially in the chemical process industries and in foam rubber production.

It is especially the developments in the chemical utilization of hydrogen peroxide which promise to bring about a major change in the civilian distribution pattern for hydrogen peroxide — a trend which has already taken on substance during the last few years.

These developments on the market side are matched by changes in the production picture. Wholly new processes for

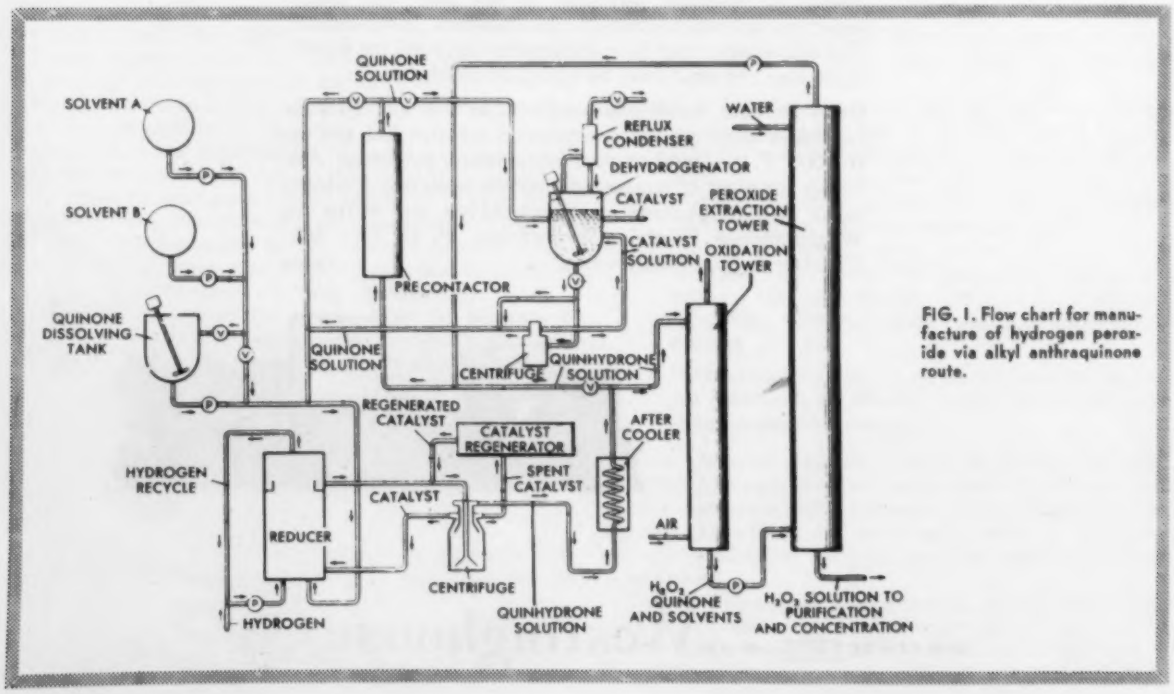

FIG. 1. Flow chart for manufacture of hydrogen peroxide via alkyl anthraquinone route.

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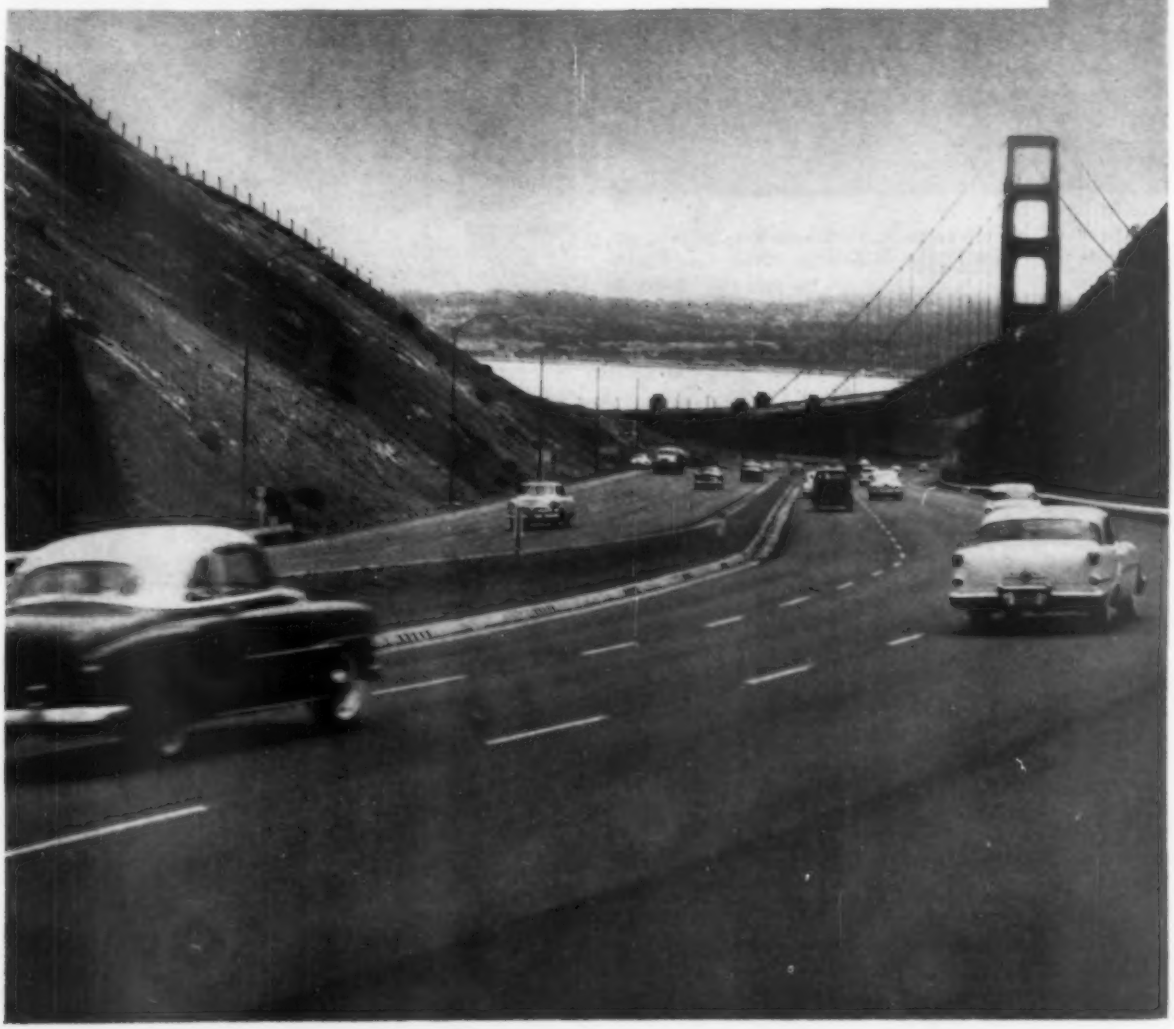


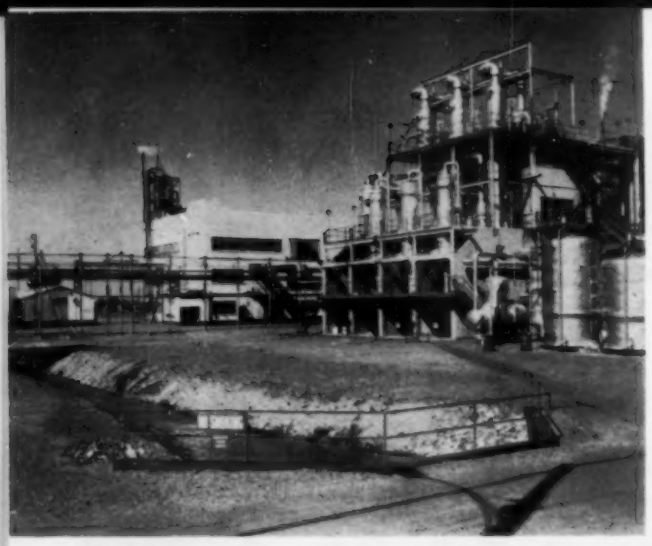


FIG. 2. Reactors, fractionators in a non-electrolytic hydrogen peroxide plant. — Courtesy Solvay Process Division.

hydrogen peroxide synthesis and product concentration have been commercialized since 1953.

Until mid-1953, America's entire supply of hydrogen peroxide had been obtained (a) by decomposition of barium peroxide; and (b) by electrolytic processes.

The older barium peroxide process accounted for only a small portion of the nation's output in the early 1950's. Of the five plants in 1952, only one (Westvaco Company at Carteret, New Jersey) continues to find it profitable — presumably because of an adequate market for by-product barium salts. The others in operation at that time (Buffalo Electro-Chemical Company with 2 plants, E. I. duPont de Nemours and Company, and Pennsylvania Salt Manufacturing Company) relied on electrolytic methods of hydrogen peroxide manufacture.

In brief, the barium peroxide process involves three chemical steps. The first is the calcination of barium carbonate in the presence of carbon (to favor the reaction equilibrium by conversion of by-product carbon dioxide to carbon monoxide):

$$BaCO_3 + C \xrightarrow[1450\ C]{} BaO + 2CO \quad . \quad . \quad . \quad . \quad . \quad (2a)$$

Product barium oxide is converted by air oxidation at 750-800 C:

$$BaO + \tfrac{1}{2}O_2 \rightarrow BaO_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2b)$$

Finally, barium peroxide is converted to hydrogen peroxide by treatment with sulfuric acid:

$$BaO_2 + 2H_2SO_4 \rightarrow H_2O_2 + BaSO_4 \quad . \quad . \quad . \quad . \quad . \quad (2c)$$

(Other acids, notably phosphoric, have also been used in lieu of sulfuric acid.)

More important as a source of hydrogen peroxide are — and have been for over two decades — electrolytic processes. In this category, we find three commercial approaches. Oldest of these is the peroxydisulfuric acid process in which electrolysis takes place according to Equation (3a) and is followed by hydrolysis as shown by Equation (3b);

$$2H_2SO_4 \rightarrow H_2S_2O_8 + H_2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3a)$$

$$H_2S_2O_8 + H_2O \rightarrow 2H_2SO_4 + H_2O_2 \quad . \quad . \quad . \quad . \quad . \quad (3b)$$

A subsequent development was the potassium peroxydisulfate process, an electrolytic method which has been practiced commercially in Europe, but not in this country.

Electrolysis:

$$2NH_4HSO_4 \rightarrow (NH_4)_2S_2O_8 + H_2 \quad . \quad . \quad . \quad . \quad . \quad (4a)$$

Precipitation:

$$(NH_4)_2S_2O_8 + 2KHSO_4 \rightarrow K_2S_2O_8(\text{insol.}) + 2NH_4HSO_4 \quad . \quad . \quad . \quad . \quad . \quad (4b)$$

Hydrolysis:

$$K_2S_2O_8 + 2H_2O \xrightarrow{(H_2SO_4)} 2KHSO_4 + H_2O_2 \quad . \quad (4c)$$

Finally, there is the ammonium peroxydisulfate process, which is today the most important electrolytic method for hydrogen peroxide production practiced in this country:

Electrolysis:

$$2NH_4HSO_4 \rightarrow (NH_4)_2S_2O_8 + H_2 \quad . \quad . \quad . \quad . \quad . \quad (5a)$$

Hydrolysis:

$$(NH_4)_2S_2O_8 + 2H_2O \rightarrow 2NH_4HSO_4 + H_2O_2 \quad . \quad (5b)$$

For a more detailed account of the electrolytic and barium peroxide processes, the interested reader is referred to a recent book by Schumb et al.[5]

The year 1953 marked a turning point in the American hydrogen peroxide industry. During that year, DuPont's Memphis, (Tennessee) plant began the commercial production of hydrogen peroxide by a fully competitive non-electrolytic (petrochemical) process which involved the autoxidation of a 2-alkylhydroanthranquinone followed by reduction of the product 2-alkylanthraquinone. This carrier compound is derived from two petrochemicals — alkylbenzene and phthalic anhydride. Production of these intermediates from petroleum sources has been discussed by Sherwood elsewhere.[7,8]

This was not the first production of hydrogen peroxide via organic intermediates. In the early 1940's, Mathieson gave an 18-month try-out to a method in which para-azotoluene is reduced by nascent hydrogen (generated from sodium amalgam, an electrolytic product) and the resulting hydrazotoluene is oxidized by air to yield recycle azotoluene and hydrogen peroxide.

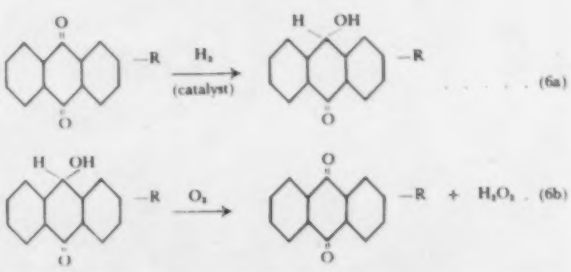
However, the alkylanthraquinone process (a version of earlier work by I. G. Farbenindustrie) was the first method of its type which has proved commercially successful. Modification of the process has since been started up by Solvay at Syracuse and is believed to be the basis for Columbia-Southern's plant announced for Barberton, Ohio.

There are other approaches which lead to hydrogen peroxide via organic intermediates. One of these, involves the partial oxidation of lower hydrocarbons (propane or butane). Another converts isopropanol to acetone and hydrogen peroxide and is reported to be the basis for Shell Chemical's hydrogen peroxide plant at Norco, Louisiana.

With these processes, hydrogen peroxide has moved definitely within the scope of the petrochemical industries. The following sections of this article will be a discussion of technical aspects of the three routes to hydrogen peroxide involving these organic intermediates: (1) Alkyl anthraquinone; (2) lower hydrocarbons; and (3) isopropanol.

A. Alkyl Anthraquinone Route to Hydrogen Peroxide

Of the three methods under discussion, this has found the most important commercial application since its first commercial employment in 1953. Underlying are reactions (6a) and (6b):



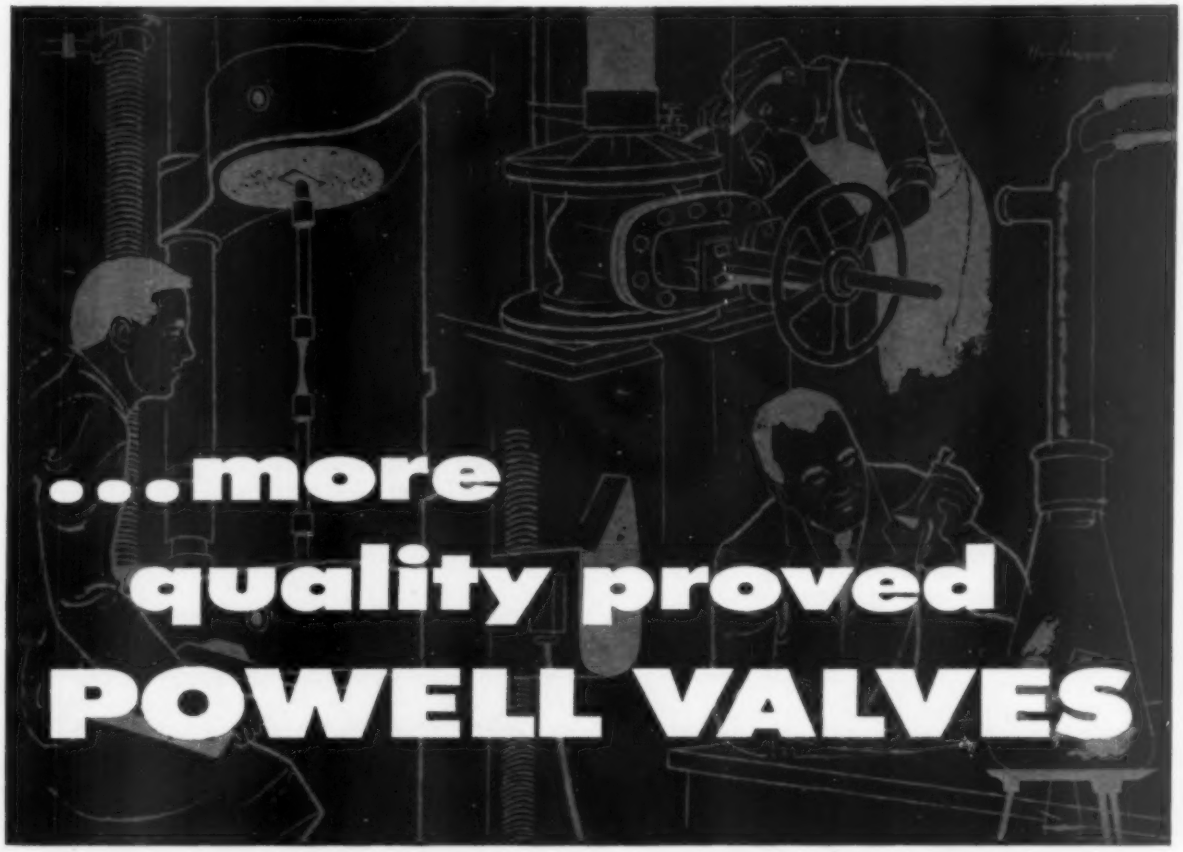
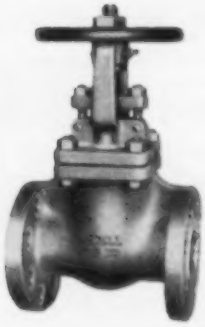


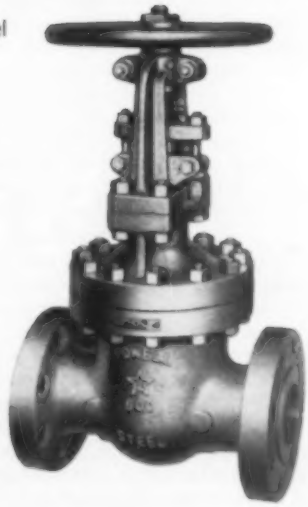
FIG. 375—Bronze "White Star" Gate Valve for 200 pounds W.S.P.

FIG. 2467—Stainless steel O.S. & Y. Gate Valve for 300 pounds W.P.

FIG. 6003—600-pound Steel O.S. & Y. Gate Valve

FIG. 3061—300-pound Steel Swing Check Valve





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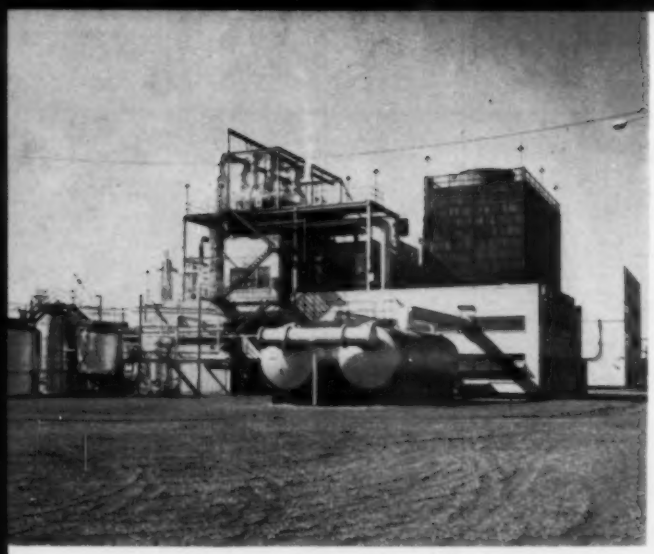


FIG. 3. View of Solvay's hydrogen peroxide plant at Syracuse, New York. — *Courtesy Solvay Process Division.*

A variety of alkylated anthraquinones may be taken through this autoxidation-reduction cycle to yield hydrogen peroxide. The 2-ethyl derivative has been generally preferred because of favorable solubility and reaction rate characteristics. There is evidence, however, that one American producer has selected 2-butyl anthraquinone instead.

Fig. 1 illustrates a typical continuous flow sheet for the ethyl anthraquinone process. The quinone is dissolved in a solvent system to yield a solution of about 10 percent strength. This stream is fed to the reduction chamber where it is joined by finely divided hydrogenation catalyst and contacted with gaseous hydrogen for the execution of Reaction (6a). Conversion is about 90 percent.

The effluent from the reduction chamber is freed of suspended catalyst by centrifuging (or filtration). The solids are returned to the hydrogenation stage. A side stream of this recycle catalyst is taken off for regeneration en route to the reduction (hydrogenation) chamber.

Quinhydrone solution leaving the centrifuge as filtrate is cooled (to remove the heat of hydrogenation which it carries as sensible heat). The stream is then split. About 90 percent is taken directly to the oxidation tower where it is contacted with air to convert the quinhydrone to the quinone plus hydrogen peroxide in accordance with Equation (6b).

No catalyst is employed in the oxidation tower. However, the use of air as such is only possible in conjunction with high-boiling solvents. At least one commercial installation has used benzene as one component of the solvent system. In this instance, there was enough danger of forming an explosive mixture with air that the gas stream fed to the oxidation tower had to be diluted with nitrogen.

The effluent from the oxidation tower contains primarily hydrogen peroxide, ethyl anthraquinone and the solvents employed in the process. This stream is fed to an extraction column where it is contacted with water for hydrogen peroxide removal. The resulting aqueous hydrogen peroxide solution is at 10 to 20 percent strength. This is the crude product which must be upgraded to meet commercial requirements by means of purification and concentrating methods which will be discussed below.

The organic raffinate, leaving the top of the extraction column still contains a small quantity of hydrogen peroxide which acts as catalyst poison in the hydrogenation stage. It is therefore necessary to destroy this residual hydrogen peroxide. Toward this end, the raffinate stream is treated with nickel-silver catalyst which decomposes the hydrogen peroxide to oxygen plus water. Before or after catalyst addition, the system is joined by the 10 percent bleed stream of hydrogenated working solution leaving the aftercooler quinone reduction step. The quinhydrone in this working solution serves to absorb the oxygen liberated by hydrogen peroxide decomposition.

Purified solution is then returned for further hydrogenation, thus completing one cycle.

There are several modifications of this process differing principally in two aspects: (1) Choice of solvent, and (2) means for suppressing the conversion of the anthraquinone to the corresponding tetrahydroquinone (THQ) during the reduction step or means for reconverting the THQ, once formed, to the more active anthraquinone.

1. **Choice of solvent.** Ideally, the solvent for ethyl anthraquinone has the following characteristics: (a) Large dissolving power for the reagent, in both its quinone and quinhydrone form; (b) low vapor pressure; (c) negligible solubility in water; (d) inertness at reaction conditions; (e) a high distribution coefficient for hydrogen peroxide between water and the solvent. Furthermore, the solvent must not have adverse effect on the rate of reactions (6a) and (6b).

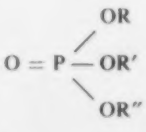
First commercial installation for the autoxidation process (at Ludwigshafen) carried the ethyl anthraquinone as 10 percent solution in a 50:50 mixture of benzene and $C_9 - C_{11}$ secondary alcohols. In this system, the hydrocarbon will dissolve the quinone but has practically zero dissolving power for the hydroquinone. Higher aliphatic alcohols are therefore made part of the solvent system in order that the hydroquinone may be solubilized. But even in this system, the hydroquinones are not very soluble. Therefore, it becomes necessary to recycle a very large amount of solvent per unit hydrogen peroxide. With ethyl anthraquinone used in 10 percent concentration about 20 gal solution must be taken through one complete cycle for every pound hydrogen peroxide recovered.

Use of benzene has other drawbacks as well. Above all, its high vapor pressure and flammability makes the use of air in the oxidation stage too hazardous so that dilution by nitrogen becomes necessary. Also, it is necessary to use a thiophene-free grade of benzene because presence of sulfur in the system would immediately poison the hydrogenation catalyst.

Some of these drawbacks are overcome by the use of alternate mixtures of aromatic hydrocarbons and higher aliphatic alcohols (e.g., xylene and methyl cyclohexanol) which do not, however, permit ethyl anthraquinone concentration much in excess of 10 percent.

Chemical Week[9] states that the solvent employed at Solvay's new hydrogen peroxide plant is a mixture of acetophenone and capryl alcohol. In this system, the anthraquinone solvent is the ketone (acetophenone). Some reference is also found in the literature to the use of ethers in this function but their commercial use has not become known to this writer.

Considerable interest attaches to the use of organic esters of phosphoric acid in lieu of the hydroquinone-solubilizing aliphatic alcohols. These esters have the general structural formula:



According to Buffalo Electro-Chemical Company's Dawsey[10] phosphate esters with three alkyl groups generally exhibit a high solubility for the hydroquinones together with low solubility for the corresponding quinones. Progressive substitution of aryl for alkyl groups in the R, R′ and R″ positions, however, raise the relative quinone solubility with simultaneous lowering of the solvent's capacity for dissolving hydroquinone compound. Table 2 illustrates this trend:

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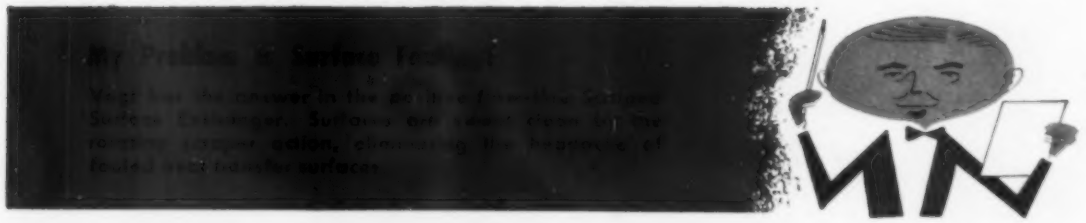

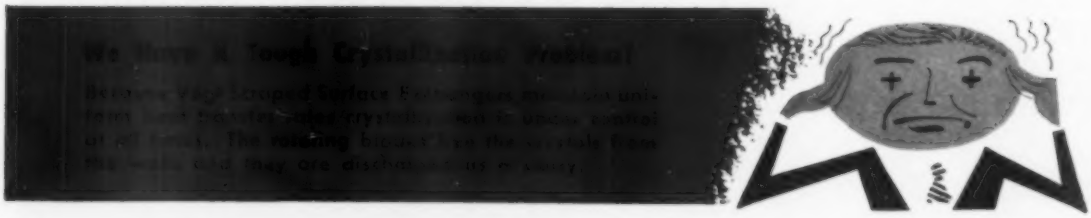

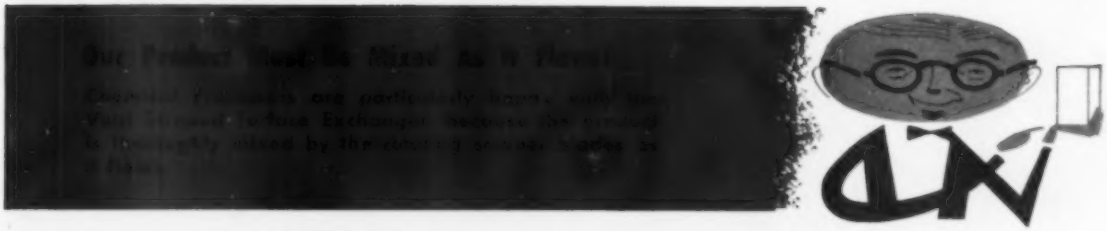

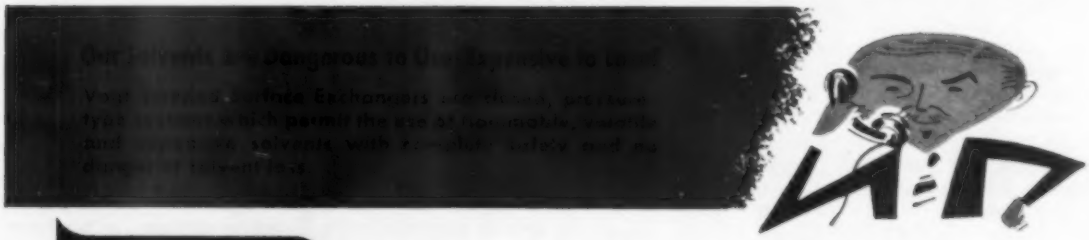

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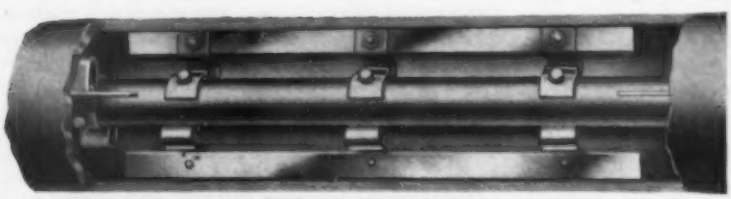

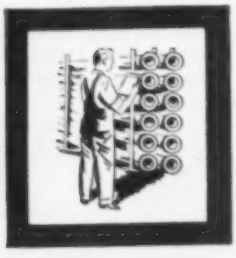

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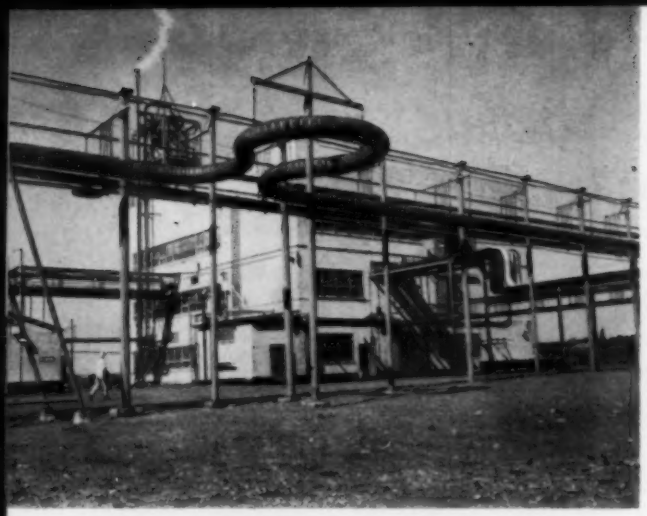


FIG. 4. Several of the main process lines in a peroxide plant: Note the heavy insulation required.

TABLE 2.

Solvent	Solubility (g/liter solvent)	
	Quinone	Hydroquinone
Tributyl phosphate	57	336
Trioctyl phosphate	40	202
Diphenyl octyl phosphate	72	165
Diphenyl cresyl phosphate	106	137
Tricresyl phosphate	123	154

It is seen that tricresyl phosphate has suitable solvent characteristics for both the quinone and the hydroquinone forms. But even better solvent action is obtained in a mixture of tributyl phosphate (for the hydroquinone) and aromatic hydrocarbon (for the quinone). Thus, 210-g 2-ethyl anthraquinone may be dissolved in one liter of a 1:2 (volumetric) mixture of tributyl phosphate and benzene. For this system, Dawsey claims formation of one pound hydrogen peroxide per nine gallons solvent taken through one reduction-oxidation cycle; i.e., the rate of solvent circulation is about one-half that reported above for the benzene-alcohol solvent system.

2. **Hydrogenation conditions.** The hydrogenation step (Reaction 6a) is normally carried out at 25 to 35 C and at a hydrogen pressure of 15 psig. Catalyst is normally Raney nickel, but the use of palladium has also been mentioned. The amount of catalyst is between 5 to 10 percent by weight of quinone present. It is introduced as a dispersion in one of the solvents, e.g., in benzene.

We have already noted that the absence of sulfur compounds and of hydrogen peroxide must be ensured at this stage, since both are catalyst poisons. Converter vessel is not cooled. Exothermic reaction heat therefore causes an increase in the reaction stream's temperature from 25 C in feed to 35 C in effluent.

In the course of the reduction step, a portion of the ethyl anthraquinone (EAQ) is reduced to the corresponding tetrahydroquinone (THQ). This is objectionable, not only because it leads to increased hydrogen consumption, but most especially because the tetrahydroquinone compound is much less reactive than its parent compound in the autoxidation as well as in the hydrogenation stages of the process. This is illustrated by the relative reaction rates observed for the two types of compound in both process stages, as shown in Table 3.

It is evident that steps must be taken to suppress the formation of the tetrahydro compound as much as possible or else to regenerate the working solution from time to time so as to reconvert THQ to the more useful anthraquinone.

TABLE 3.

Temp C	EAQ:THQ Relative rates of hydrogenation	EAHQ:THHQ Relative rates of oxidation
30	3.0	2.8
50	2.1	3.7

In the original commercial version, conversion in the reduction chamber was about 90 percent complete (controlled, at the operating conditions cited above, by holding residence to 30 minutes). More recently, the claim has been made[11] that tetrahydroquinone formation can be held to a more workable level by limiting hydrogen pressure to 12 psig and conversion to 70 percent. This approach has, of course, the drawback of further increasing the amount of solution which must be circulated per unit production. Furthermore, the amount of THQ in solution is still built to a disturbingly high level. For practical purposes, the THQ content should not exceed 5 to 10 percent of total anthraquinone present.

A solution to the problem of THQ buildup rests in reconversion by dehydrogenation. For this purpose, a side stream of working solution is withdrawn at a convenient point following hydrogen peroxide removal. This bleedstream is subjected to catalytic dehydrogenation.

According to Corey and Harris,[12] sufficient dehydrogenation may be brought about by treating 25 to 50 percent of the working solution with palladium catalyst (10 wt percent on anthraquinone) at 150 to 200 C and in the absence of hydrogen. Initial dehydrogenation rate is rapid but it drops off rapidly as the THQ content of the solution is lowered. For practical reasons, therefore, the THQ content of the dehydrogenator make is not taken below 4 to 5 percent.

Palladium catalyst may be carried along with the working solution to serve as catalyst in the subsequent reduction step. Alternately, it may be removed by filtration and replaced with Raney nickel for the hydrogenation stage.

As we have noted, the formation of THQ compounds is objectionable because of their slow rate in the hydrogen peroxide-forming reactions. But, in addition, there are other degradation products formed in the autoxidation step and even more in the reduction stage, which are completely inert to the desired reactions. According to Sprauer[13] it is possible to regenerate spent solution to about 85 to 90 percent of its initial effective quinone content by heating it to 100 to 130 C in the presence of activated alumina or active magnesia.

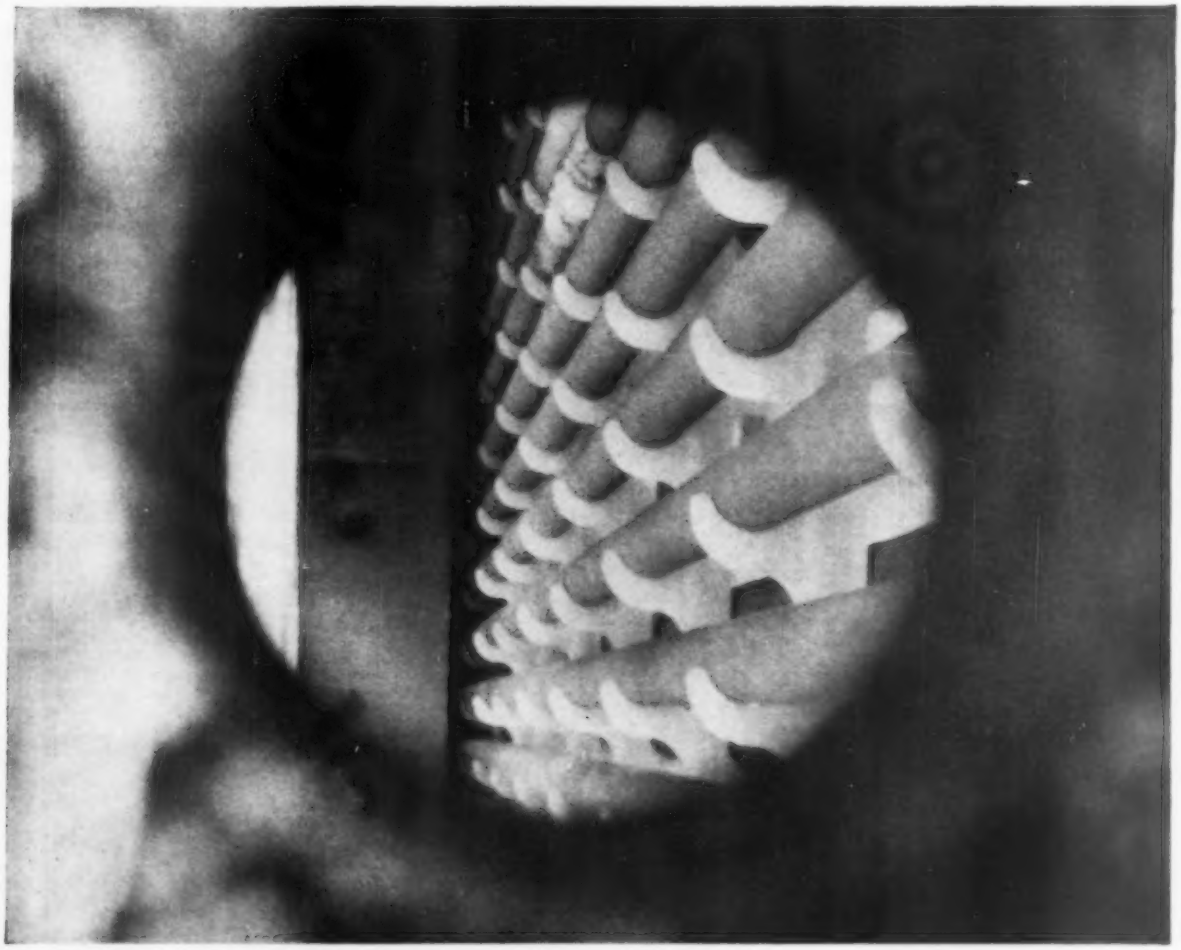
In the hydrogen peroxide process here described, replacement of degraded (and lost) 2-ethyl anthraquinone is an important cost item. Typical performance in commercial operation will yield 25 to 30 lb hydrogen peroxide per pound make-up ethyl anthraquinone charged to the cycle.

3. **Oxidation conditions.** Autoxidation of the quinhydrone (Reaction 6b) is carried out non-catalytically by the use of air (which may have to be diluted by nitrogen, as has been noted above). A tower is used for the oxidation stage in which the oxidizing gas is bubbled through the solution at 30 to 35 C. Substantially complete conversion is taken in this pass, yielding a product which contains 0.6 to 1.0 percent hydrogen peroxide.

Care must be taken that the hydrogenation catalyst is quantitatively removed from the solution before it enters the oxidation tower since this catalyst also promotes the decomposition of hydrogen peroxide, the desired product.

Certain decomposition and oxidative products are unavoidably formed in the course of the oxidation-reduction cycle. Other contaminants (such as iron and nickel) enter the working solution from the equipment and catalyst. If permitted to build up indefinitely, these materials will eventually find their way into the hydrogen peroxide via the aqueous extraction stage. It is necessary to withdraw a small bleedstream from the system and to purify its contained anthraquinone and solvents by distillation methods, whereupon the recovered materials are returned to the process. Metallic contaminants which enter the hydrogen peroxide anyway may be removed by ion exchange methods which we shall discuss in Part 2.

Part 2 will appear in a future issue of THE REFINING ENGINEER.



A peep inside shows...

Why Gulf puts Incoloy alloy tubes in hottest zone of heaters

The condition of these extruded Incoloy* nickel-chromium-iron alloy tubes speaks volumes.

No cracks. No warps. No thick scale. These tubes have seen thousands of hours of service in cracking hydrocarbons to produce ethylene at Gulf Oil Corporation's million-pound-per-day capacity Port Arthur plant. At this same plant their performance has been duplicated many times over.

After 9000 hours service from Incoloy alloy tubes in one group of furnaces, for example, Gulf stated: "Maintenance has been very slight ... mainly replacing one or two feet at the outlet end of several tubes" (an easy repair with weldable Incoloy alloy.)

One thing that makes Incoloy alloy so reliable in this service is the stability of its austenitic structure. Another is its high resistance to carburization ... a safety factor during decoking.

Gulf also realizes a distinct price advantage in using Incoloy alloy tubing in the relatively inexpensive extruded form.

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Booklet briefs Incoloy data

Information on the composition, properties, fabrication and heat treatment of Incoloy alloy have been briefed for you in the Inco booklet. "Properties of Incoloy." Let us know if you would like a copy... or if Inco's Development and Research Division can be of service.

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Nomograph for Sensitivity of Hydrocarbons and Gasolines

George E. Mapstone

THE difference between the Research or F.1 octane rating of a fuel and its motor or F.2 octane rating is referred to as the sensitivity of the fuel. The property depends on the hydrocarbon composition of the fuel and its TEL content. Maples[1] has recently derived relationships between the Research and motor octane ratings of the various classes of hydrocarbons and of the typical gasolines produced by different refining processes. These relationships cannot be taken as exact for any particular sample of gasoline or hydrocarbon but prove most valuable when trends or average results are required.

Key, Nomograph for Sensitivity of Hydrocarbons and Gasolines.

Hydrocarbon or gasoline.	T E L	X	Y
Paraffins	clear	8.6	16.9
Paraffins	3 ml	7.9	17.6
Naphthenes	clear	7.3	14.3
Naphthenes	3 ml	5.0	15.6
Mono olefines	clear	0.9	15.3
Mono olefines	3 ml	2.6	13.9
Cyclo olefines	clear	18.2	0.9
Cyclo olefines	3 ml	14.5	2.0
Straight run	clear	6.2	14.1
Straight run	3 ml	7.4	15.3
Catalytically reformed	clear	4.6	14.3
Catalytically reformed	3 ml	3.0	16.9
Thermally cracked or reformed	clear	3.2	13.6
Thermally cracked or reformed	3 ml	0.8	17.1
Catalytically cracked	clear	3.2	13.5
Catalytically cracked	3 ml	1.2	16.0
Catalytically polymerized	clear	0.4	14.9
Catalytically polymerized	3 ml	2.6	13.9

This nomograph has been designed to present these relationships in a convenient and compact form. To use the chart, first locate the coordinates of the sample in the hatched area and then connect by means of a straight edge to the given octane rating (Research or motor method). The line will cut the other octane rating scale at the required value.

For example, it is desired to estimate the motor method octane rating of a 90 Research O. N. catalytically cracked gasoline containing 3 ml TEL per gal. From the key, the coordinates for a catalytically cracked gasoline containing 3 ml TEL per gal are X = 1.2, Y = 16.0. Connecting this point by means of a straight edge with 90 Research octane number gives 80.5 motor method octane number.

Reference

1. Maples, R. E., *Petroleum Refiner*, 33; (9), 284-299, (1954).

★ ★ ★

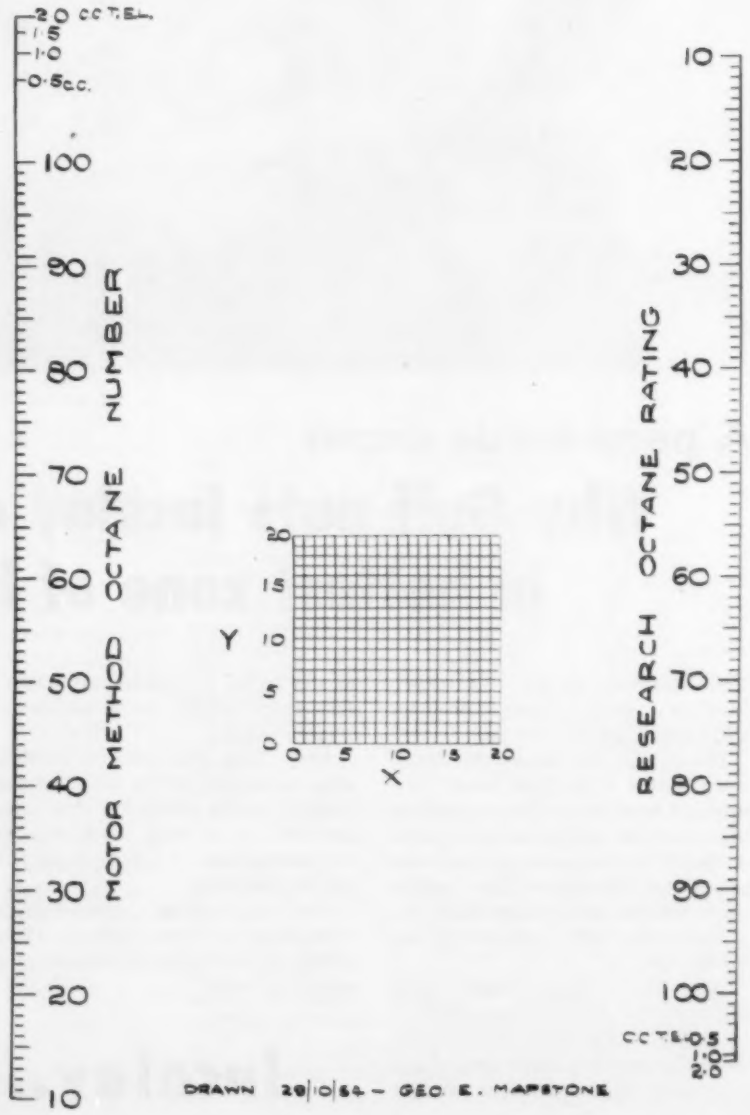


FIG. 1. Nomograph for estimating octane number sensitivity of hydrocarbons and gasoline.

REFINING Personals

▸ **Dr. W. B. Franklin** is one of the 14-member Advisory Council for the newly formed Engineering Foundation of the College of Engineering at The University of Texas. At present Dr. Franklin is acting manager of refining technical and research division in Humble Oil & Refining Company's executive development program.

Dr. W. B. Franklin

W. G. Eddleman

W. G. Eddleman, senior project engineer at Shell Oil Company's Wood River, Illinois, refinery, has been promoted to assistant chief engineer with offices at the company's Houston, Texas, refinery. He had served as industrial planning, area and project engineer prior to this promotion.

L. A. Bullington

R. A. Dreselly

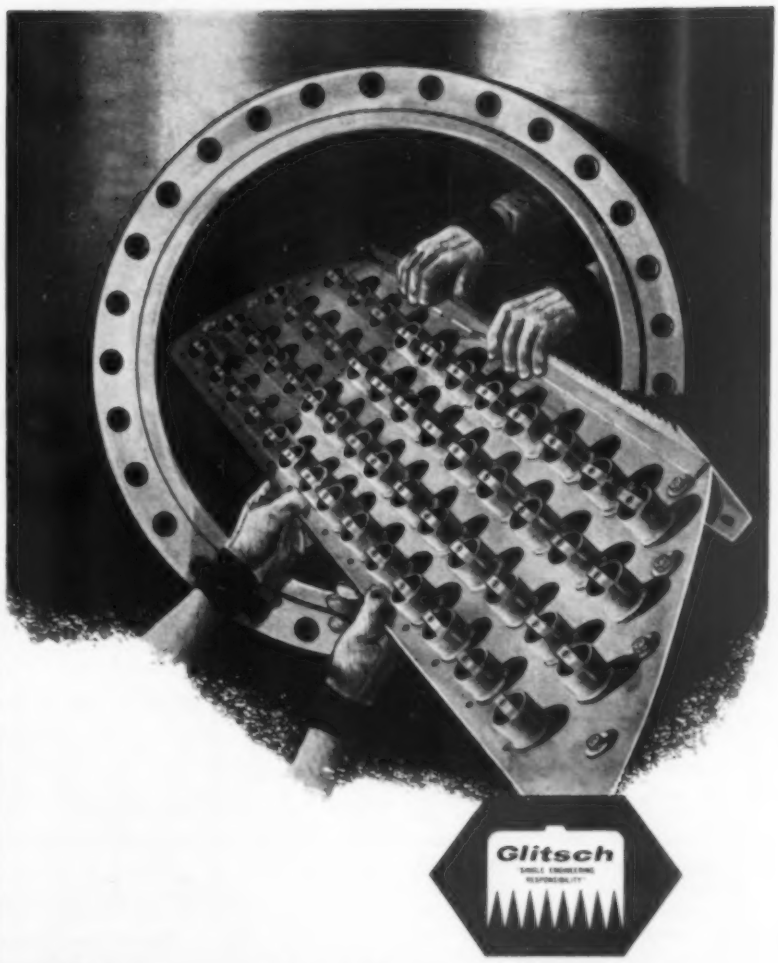
▸ **L. A. Bullington** has been promoted to technical specialist and **R. A. Dreselly, A. R. Dudley** and **R. F. Pfennig** have been named section heads in technical service division at Humble Oil & Refining Company's Baytown, Texas, refinery.

A. R. Dudley

R. F. Pfenning

T. M. Babin, H. A. Bordelon, L. D. Olafson, J. R. Samway, D. C. Seamans and **R. H. Walton** have been promoted in the engineering division at the Humble refinery. Babin and Seamans are now senior mechanical engineers, and Olafson is a senior maintenance engineer.

Humble Oil has also announced the promotion of **H. G. Boynton, E. W. Lewis,** and **J. R. Miller** to senior research chemical engineers in research and development division at the Baytown refinery, and **J. R. Lander** and **W. G. Denning,** in technical service division, named senior chemical engineers.



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Thermocouple for Reducing Atmospheres

Q Have here been any thermocouples recently developed that show long life and good thermal emf stability in reducing atmospheres?

D.D.F.

A New thermocouple has been developed for the primary purpose of withstanding industrial reducing atmospheres at high temperature. Covered by U. S. Patent No. 2,691,690 issued October 24, 1954, tests on it have shown a minimum in emf drift compared to other alloys used in similar service. Normal compositions of the two legs are shown in Table 1 while Fig. 1 is the nominal emf-temperature relationship for the couple.

While the thermal emf response for the new couple is lower than that of the more commonly used Nichrome-Alumel couple, the sensitivity is essentially the same for both in the higher temperature ranges where they are usually employed. And, much higher stability is claimed for the new couple.

When subjected to two heating and cooling cycles between 200 and 2200F in air, excellent reproducibility was demonstrated. A portion of these data is given in Table 2. Some of the variation for the nonreproducible values may have been caused or contributed by variation in the temperature-indicating couple used for the test since it, too, was going through the heating and cooling cycles.

The relative stability of the new couple was determined by mounting it in a laboratory furnace at 1750F, adjacent to the couple in normal use. A flowing gas was passed over both couples; its nominal composition was:

CO	10 per cent
CO_2	5
CH_4	1
H_2	16
O_2	nil
N_2	balance

The furnace temperature of 1750F was chosen to simulate a condition known to accelerate green-rot attack on nickel-chromium alloys in reducing atmospheres. Exposed to the reducing atmosphere for 212 hours, the new couple (consisting of alloys No. 242 and 33) drifted only +0.13 mv, while the comparison couple drifted –7.54 mv. Another test, lasting for 171 hours, caused the new couple to drift but +0.01 mv while the comparison unit drifted –7.92 mv. Test results on four couples, including the new unit, run at 1750 F in the reducing atmosphere showed the following variations in thermal emf:

Ni.10Cr & 33	—7.86mv
Ni.10Cr & NiMnAlSi (conventional couple)	—7.92mv
242 & 33 (new couple)	+0.01mv
242 & NiMnAlSi	+0.11mv

Examination of these data show that the 242, 33, and Alumel legs contribute the least to the variation in thermal emf in the presence of a reducing atmosphere.

It is reasonable to assume, in normal operations, that as the thermal emf response of a couple employing the 90 Nickel, 10 Chromium decreases, the temperature in the furnace increases. Damage could conceivably result. The new couple rises a relatively small amount with time; furnace or stack temperature thus would decline slightly . . . if it is a control point . . . with no adverse consequences other than a small drop in throughput or an increase in excess air. ★ ★ ★

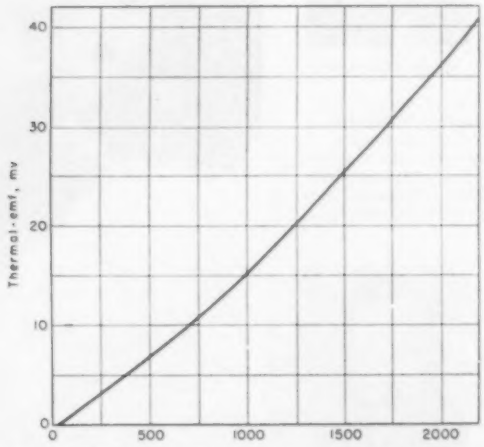


FIG. 1. Thermal-emf-temperature curve No. 242 and 33 alloys couple. Reference Junction 32F.

TABLE 1. Nominal Compositions of Alloy No. 242 & 33 Thermocouple.

Positive Leg (No. 242 Alloy)	Negative Leg (No. 33 Alloy)
20.0 per cent Cr	3.0 per cent Si
1.0 per cent Cb	0.05 per cent C
1.0 per cent Si	Balance is Ni
0.1 per cent C	
Balance is Ni	

TABLE 2. Reproducibility of a Representative Couple in Two Heating and Cooling Cycles, Between 200 and 2200 F in Air.

	Thermal emf			
Temp, F	First Heating	Second Heating	First Cooling	Second Cooling
200	2.2	2.2	2.2	2.3
400	5.0	5.1	4.9	5.0
600	8.1	8.2	8.0	8.0
800	11.4	11.55	11.4	11.4
1000	14.9	15.1	15.0	15.0
1200	18.85	18.9	18.9	18.9
1400	22.9	22.9	22.9	22.9
1600	27.0	27.0	27.0	27.0
1800	31.2	31.3	31.2	31.2
2000	35.6	35.8	35.6	35.6
2200	40.4	40.6	40.4	40.4

Adapted from article in ASTM Bulletin, No. 216, September 1956, by Charles L. Guettel, Driver-Harris Company, Harrison, New Jersey.

DU PONT *Petroleum Chemicals* NEWS

Number 78 in a Series of Bulletins for the Petroleum Industry

AUGUST 1957

Three major projects insure still better TEL delivery, service

NEW ASSISTANT TO THE TECHNICAL MANAGER

ANTON O. MELBY is assistant to the Technical Manager of the Du Pont Petroleum Chemicals Division. His duties involve the coordination of both technical service and new product development.

He came to this post from the Du Pont Petroleum Laboratory where he was in charge of the gasoline additives division. Among the projects of this group was the development of Dimethyl Formamide (DMF) as a gasoline anti-icing agent. Prior to this he was supervisor of the Petroleum Laboratory group working on combustion and scavenging.

In connection with his work at the Laboratory, Mr. Melby published a number of technical papers on combustion reactions and the effect of additives. Among them are papers titled: "An Investigation of Pre-ignition in Engines," "The Effects of Fuel Additives on the Precombustion Reactions of n-Heptane."

Following three years of service in the Army during World War II, Mr. Melby earned a B.S. degree in chemical engineering at the University of Wisconsin. He then continued his studies, at the University of Michigan, receiving an M.S. degree there in 1949. He joined the Du Pont Petroleum Laboratory staff in 1950.

He is a member of the Society of Automotive Engineers and the Petroleum Division of the American Chemical Society.

Du Pont adds important facilities in first half of '57

The new TEL storage and delivery terminal at Beaumont, Texas, is the latest addition to the rapidly growing list of Du Pont facilities for serving the company's TEL customers.

Earlier this year the TEL tank-ship, *MV Petrochem*, which was commissioned two months ago, became another major addition to Du Pont's tetraethyl lead distribution setup. The Petroleum Chemicals Division's new TEL manufacturing plant has been completed at Antioch, California. It is the only TEL plant located in the important West Coast refining area.

THE RECENTLY COMPLETED Du Pont TEL terminal at Beaumont, Texas. It contains complete modern facilities for the storage and handling of TEL, and rapid dispatch of loaded tank cars.

The new Beaumont terminal, which represents an important delivery convenience for Gulf Coast refiners, will be supplied from the Du Pont TEL plant at the Chambers Works, Deepwater, N. J., by the tank-ship.

The terminal has ample storage capacity to meet the expanding TEL requirements of the Gulf Coast refineries. It contains complete TEL handling facilities. A rail siding on the property means that a number of TEL tank cars can be pre-loaded there and be ready for immediate dispatch to any refinery in the area. A dock and special unloading equipment for the new tank-ship are also important segments of the operation.

This means that the new Beaumont terminal is equipped to provide refiners with the same TEL availability and fast delivery service as Du Pont's manufacturing plants.

Unique ship

The *MV Petrochem* is a two-cargo vessel. Designed primarily to move bulk

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

OVER

DUPONT *Petroleum Chemicals* NEWS

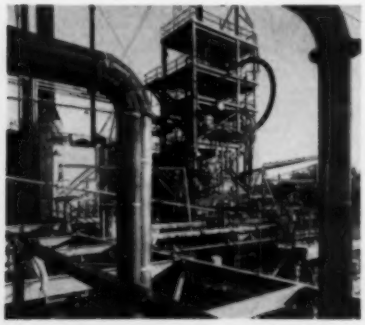
CONTINUED *Major Projects*

shipments of TEL south, she is equipped also for transporting ethyl chloride and ethylene dichloride on the northbound sailing.

THIS 6,000-TON SHIP, *MV Petrochem,* **is the first overwater chemical carrier to transport TEL compound in bulk.**

New West Coast Plant

DuPont's new TEL manufacturing plant at Antioch, California, was constructed to meet the needs of the fast-growing West Coast oil industry. The new plant makes possible fast, short-distance shipments of California-made TEL to all West Coast refineries.



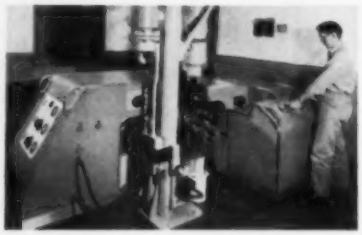
THIS NEW DuPont TEL plant in California incorporates the most modern, continuous process TEL manufacturing facilities in the world.

These three major expansions will increase even more the efficiency of the nationwide network of DuPont TEL facilities – which, as previously, includes also conveniently located rail sidings with loaded tank cars in 14 major refining areas across the country, plus the five Petroleum Chemicals Division regional laboratories and the twelve sales and service offices.

The many technical, marketing, research, safety, and operational services offered by DuPont . . . the most complete line of petroleum additives offered by any supplier . . . the new facilities–these together assure you of getting the most out of your additives program.

New facts about knock uncovered by spectrometric study at Du Pont Petroleum Laboratory

A versatile spectrometer geared to a single-cylinder engine is being used at the DuPont Petroleum Laboratory to study the reactions responsible for the cool, blue, and intense blue flames which are obtained in an engine combustion chamber as it is motored under increasingly severe operating conditions.



HERE IS the unique spectrometer used by the DuPont Petroleum Laboratory for studying the chemistry of knock and the fundamentals of combustion. The operator is shown adjusting the amplifier for recording. Part of the single-cylinder engine can be seen in the center of the picture.

As a result of these studies, spectral evidence has been found by the Laboratory indicating that these reactions progressively involve more extensive degradation and oxidation of the fuel. Hydrocarbon decomposition and formation of carbonyl compounds are involved in reactions emitting cool flames. And further oxidation of carbonyl compounds is especially important in reactions giving blue flames.

Free radical reactions

The free radical reactions occurring under intense blue flame conditions easily lead to auto-ignition and knock. But tetraethyl lead apparently interferes with this series of reactions by slowing down carbonyl decomposition reactions under blue flame conditions, possibly by deactivating free radical intermediates.

A detailed account of this study was recently published. When writing for a copy, refer to the title, "Spectrometric Investigations of n-Heptane Preflame Reactions in a Motored Engine."

New book gives detailed information about Du Pont Fuel Oil Additive No. 2

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OVER

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Pump Doctor at Work

It takes a lot more than equipment and oil to keep a petroleum refinery operating smoothly and profitably. It takes people . . . people with many different skills and aptitudes. One of the most important — and skilled — groups in a refinery are its pump doctors, the men who keep the plant's pumps running around the clock for months and years at a time. Pumps are the workhorses of a refinery; without them no motion, no action occurs, nothing is made, and the plant stagnates. How well the pump doctor does his job has a direct bearing on refinery down-time, time that has a premium price tag.

In Cities Service refineries in Ponca City, Oklahoma, and East Chicago, Indiana, some 15 pump doctors strive continuously to keep the pumps on stream and operating efficiently. They make adjustments, replace parts, repack seals, regrind valves, bearings, and cranks, rebore cylinders, and handle all of the other details of pump maintenance and smooth operation.

These photos, taken from the Cities Service *Empire* for March 1957, show a man that is typical of pump doctors all over the country, each with his finger on the mechanical pulse of his plant. To some of us, the problems that he faces may seem routine — we think that these pictures prove otherwise and that it requires years of experience and a lot of skill to handle the many diverse problems that a pump doctor must solve.

1. Meet Cecil S. (Whitey) Clayton, a pump doctor at Cities Service Oil Company's refinery at Ponca City, Oklahoma.

2. Just one of Whitey's many assignments is to keep steam turbines operating at peak efficiency at all times. Here he adjusts a steam governor on a turbine that powers a process pump at the catalytic cracking unit.

3. Planning sessions help keep everybody informed. Whitey here studies a pump setting with other mechanics and technicians.

4. Proper care can keep a pump operating for years. Whitey and a helper here overhaul a large duplex pump.

Continued ▶

Pump Doctor at Work

5. Sometimes a pump doctor gets up in the air. Here an adjustment is made to the automatic gear mechanism of the catalytic cracker regenerator pressure regulator.

6. Adjustment of a canning machine is another routine job for a pump doctor. Whitey is "micing" the rim of a lubricating oil can for accurate setting.

7. When a special part is needed in a hurry, the refinery machine shop makes it. A valve seat is being turned out as Whitey looks on.

8. Pumps are depended upon to keep operations at peak performance or, as shown here, to save lives or protect equipment. Whitey is checking the gear reducer bearings on this fire pump.

9. A pump doctor's work includes the repair of small hand tools as well as massive pumps and equipment.

10. The office staff really appreciates this job that's done by the pump doctor: Getting the office air conditioning equipment ready for summer-time duty.

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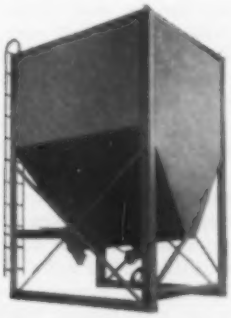

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Combustion Chamber Deposits
In High Compression Engines

M. W. Corzilius, D. R. Diggs, and R. A. Hoffman
Petroleum Laboratory, E. I. du Pont de Nemours & Company

THE demand for high-octane gasoline has been intensified in recent years by the steadily increasing compression ratios of automotive engines. The relatively higher cost of these high-octane fuels furnishes the incentive for continued efforts to reduce octane requirements by every means possible. Elimination of the octane requirement increase accompanying the formation of deposits in engines would be the ideal solution to this problem. Until this goal is achieved, however, practical improvements can be and have been realized through careful control of those factors influencing deposit harm, such as fuel and lubricant composition and engine design.

A program for the study of the combustion-chamber-deposit problem has been undertaken by the du Pont petroleum laboratory using both engines on laboratory dynamometer stands and vehicles operated under controlled conditions on the road. These tests were conducted using four different makes of overhead-valve V-8 engines. Two engines of each make were employed, one operating at 9:1 compression ratio and the other at 11:1 compression ratio. The laboratory engines, which were equipped with special instrumentation for the detection and recording of surface ignition, were operated on a medium-duty cyclic schedule until deposit equilibrium was firmly established. The road-test cars were driven over a 350-mile course, selected to include those types of driving encountered in normal passenger-car service, until equilibrium noise requirements were firmly established. This required from 5000 to 13,000 miles of operation.

Compression ratio is perhaps the most important factor in determining the fuel-quality requirement of an engine. The average increase in equilibrium noise requirement attributable to a compression-ratio increase from 9:1 to 11:1 was determined to be eight octane numbers, or 4.0 octane numbers per compression ratio, using a distillate-residuum, an all-distillate 10W-30, and a synthetic oil averaged at each compression ratio irrespective of car make. However, although the average requirement for all cars was 102.1 octane number,* one make operated noise-free on 100-octane number fuel indicating that design of the power-plant package is quite important in minimizing equilibrium noise requirement.

In order to determine the contribution of various lubricating oils to deposit harm, road tests involving all eight vehicles were conducted using a commercial SAE 20-20W distillate-residuum blend, an SAE 10W-30 all-distillate finished oil formulation, and a low-viscosity synthetic lubricant of the diester type. At both compression ratios the highest equilibrium noise requirement was observed when the distillate-residuum oil blend was employed (Fig. 1). The use of the all-distillate 10W-30 blend, which was formulated to be representative of high-quality commercial 10W-30 oils, resulted in deposit harm of about two octane numbers less. The

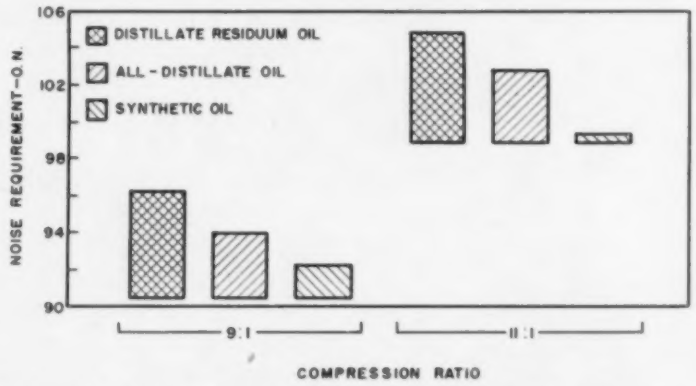


FIG. 1. Effect of lubricant type on equilibrium noise requirements of road test cars. (Lower end of bars represent clean engine requirement; upper end the equilibrium requirement.)

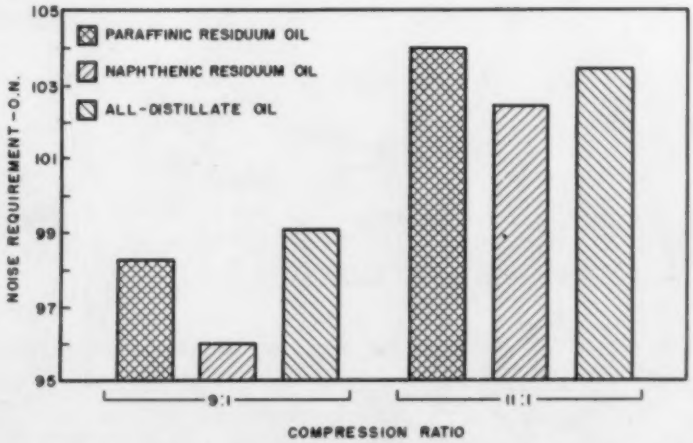


FIG. 2. Effect of lubricant type on equilibrium noise requirements of laboratory engines.

Condensed by the authors from a paper presented before the American Petroleum Institute, Division of Refining meeting, Montreal, May 15, 1956.

least deposit harm was observed when the synthetic oil was used; the advantage over the all-distillate 10W-30 being about two octane numbers.

The benefits of oils of the type represented by the all-distillate oil were apparent at compression ratios of 9:1 and 11:1, and the availability of these oils will be an important asset as compression ratios continue to increase. The results with the synthetic lubricant indicate, however, that still further reductions in deposit harm may be possible, and perhaps improvements in commercial oil formulations can make this benefit available.

As compression ratios increase, the tendency for surface ignition to occur is accentuated and, therefore, the surface-ignition activity with certain types of deposits may become important. Experimentally, surface ignition was found to be of minor importance at 9:1 compression ratio. Even at a compression ratio of 11:1, little surface-ignition activity was evident in some makes of cars, however, other makes exhibited considerably more surface ignition at the higher compression ratio. Lubricant type also affected the tendency for surface ignition with the distillate-residuum blend showing the greatest harm.

The three oils for which data were obtained in road-test cars also were evaluated in the laboratory engines. Generally good correlation was obtained between the laboratory data and the road-test data with respect to both noise requirement and surface ignition. Additional studies of lubricants were undertaken, therefore, in the laboratory engines. These studies involved the evaluation of high-viscosity petroleum fractions in 10W-30 oil formulations. The use of such materials may be attractive on the basis of improved lubricating qualities; their inclusion, however, has been believed to result in increased deposit harm. In order to determine the extent of this effect, two 10W-30 oils were formulated containing appreciable amounts of high-viscosity petroleum fractions of two different types.

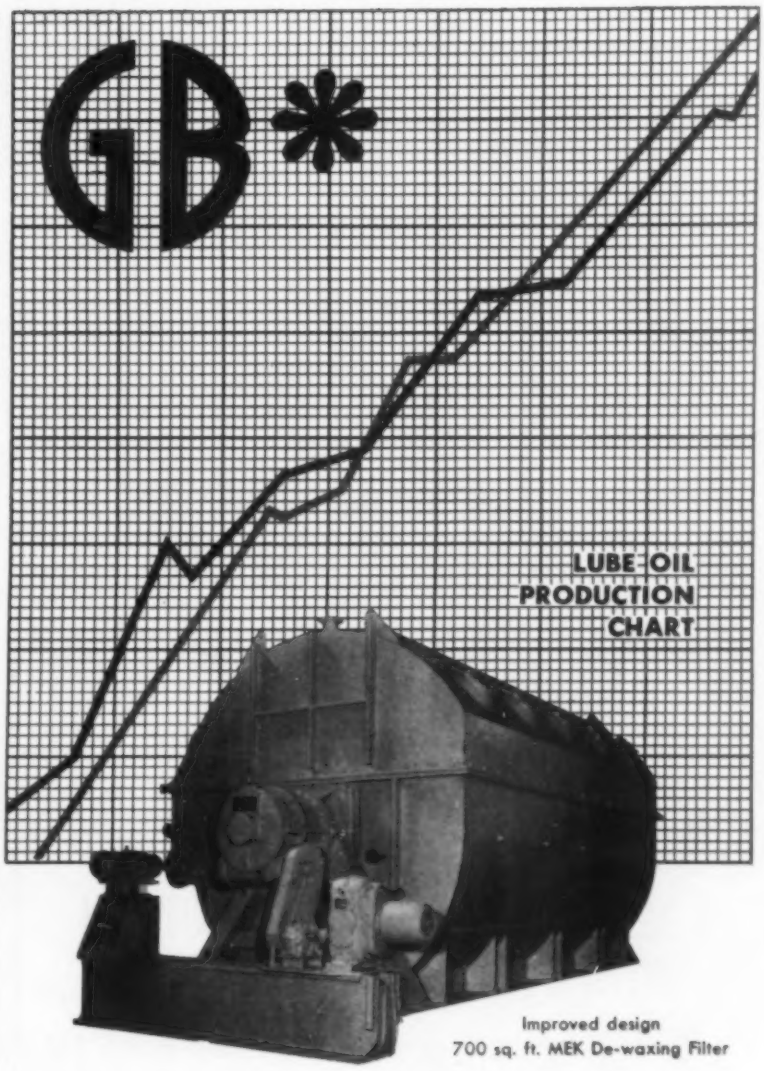
1. An SAE 10W-30 blend containing 14 per cent paraffinic bright stock. (Hereafter called the paraffinic residuum oil.)
2. An SAE 10W-30 blend containing 17 per cent of a high-viscosity naphthenic oil. (Hereafter called the naphthenic residuum oil.)

The paraffinic residuum oil was approximately equivalent in deposit harm to the all-distillate oil (Fig. 2). On the

*All octane numbers over 100 are calculated according to the following formula:

$$O.N. = 100 + \frac{PN - 100}{3}$$

O.N. = Octane Number
PN = Performance Number



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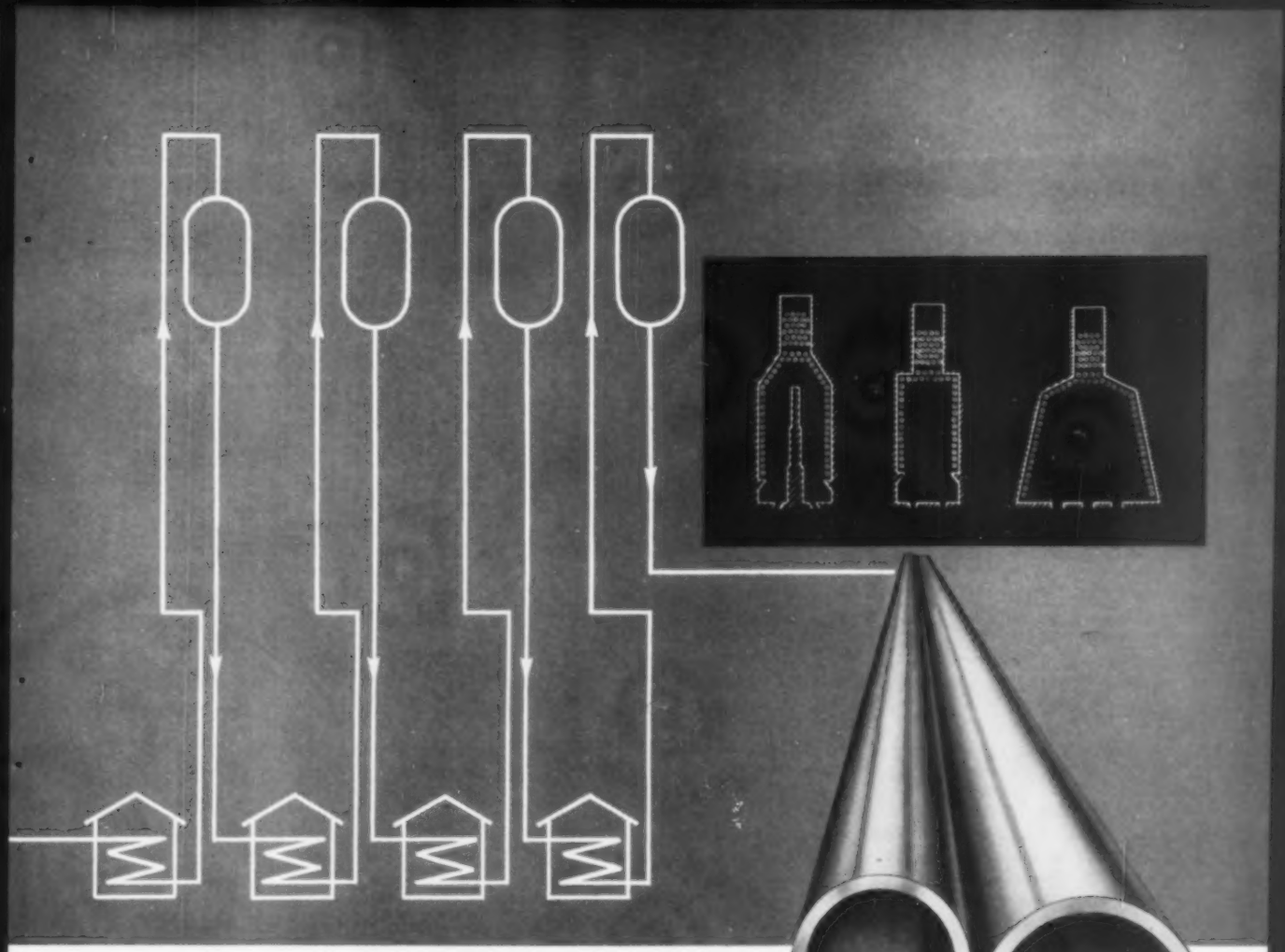
other hand, the naphthenic residuum oil actually gave less deposit harm than the all-distillate oil in three of the four cases. These results indicate that a high-viscosity petroleum fraction can be included in a 10W-30 oil formulation without adversely affecting deposit harm. In fact, if the proper choice of high-viscosity fractions and major blending components is made, less deposit harm may result. For example, the naphthenic residuum oil that gave less deposit harm than the paraffinic residuum oil contained the same low-viscosity neutral, but was thickened with a much lower boiling high-viscosity fraction.

The effects observed with these oils relative to the all-distillate oil cannot be related completely to the presence of the high-viscosity petroleum fractions, however, inasmuch as it was necessary to lower the viscosity of the major blending component at the same time the heavy materials were added. Tests with another 10W-30 oil containing the same light neutral found in the naphthenic and paraffinic residuum oils but thickened by a VI improver instead of the high-viscosity petroleum fraction, resulted in the same deposit harm observed with the naphthenic residuum oil. This result demonstrates the importance of the viscosity of the major blending component in determining the deposit harm of the oil. Apparently, the lower the viscosity of the major blending component, the less the deposit harm. It was also determined that somewhat more surface ignition accompanied the use of the high-viscosity petroleum fractions. It is believed, however, that surface ignition, to the extent observed, would not be a deterrent to the use of such materials.

The role of the fuel in contributing to combustion-chamber deposit harm was investigated with the use of three gasolines in comparison with 85A, the fuel used for the majority of the deposit-accumulation work. These fuels were made with 85A as the major constituent and with three different types of high-boiling components added. The amount of high-boiling material added was adjusted to raise the 90 per cent distilled point from 290F for 85A to 335F for the blends. This 90 per cent point was selected because it represented the average for commercial premium gasolines.

No consistent effect on deposit harm was produced by the use of any of the high-boiling materials. This indicates that gasoline volatility, as measured by the 90 per cent distilled point, is not, per se, the controlling factor in determining fuel contributions to deposit harm. The high-boiling components did not increase surface-ignition tendency.

* * *



HOW MANY PROBLEMS IN THIS PICTURE?

Some layouts present a multiplicity of engineering, purchasing, warehousing and financing problems. Conceivably, (1) Return bends have to be designed for a perfect fit on their heater tubes, (2) Both tubing and fittings must meet the same exacting customer standards, (3) Simultaneous delivery must be made to guarantee erection schedules, and (4) Money tied up in material in process at any one time must be kept to a minimum.

In such a situation, it's best to depend upon Mr. Tubes for coordinated delivery of perfectly matched tubing and fittings.

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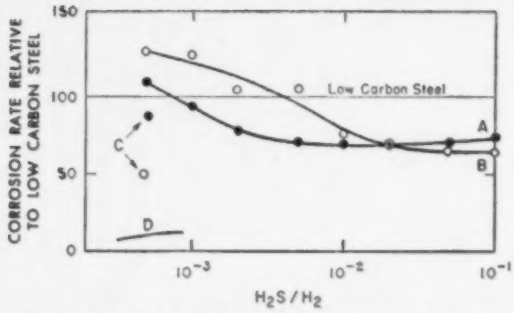
Corrosion in catalytic reforming units

Proper choice of alloys and feed desulfurization controls hydrogen attack



Comparison of corrosion resistance of several steels to hydrogen sulfide-hydrogen mixtures at atmospheric pressure.
A. Five percent chromium — ½ percent molybdenum at 985 F.
B. Five percent chromium — ½ percent molybdenum at 900 F.
C. Twelve percent chromium stainless steel at 900 F (upper point) and 985 F (lower point).
D. Eighteen percent chromium — eight percent nickel stainless steel
(Dravnieks-Samans)

THE most widely used methods for combat or control of corrosion in catalytic reformers are:

1. Proper selection of metals, with 18-8 chrome-nickel steels showing best performance at high temperatures;
2. Feedstock desulfurization — now a common practice;
3. Hydrogen sulfide removal from recycle gas, and,
4. Aluminizing of surfaces subject to attack.

These are some of the major findings of the API's Panel on Reformer Corrosion, as reported by Chairman E. B. Backensto at the API Division of Refining meeting held in Philadelphia earlier this month. Some of the more common difficulties experienced by 31 refiners participating in a survey are: Excessive metal losses; heavy furnace tube, transfer line, and heat exchanger scaling; catalyst bed plugging; furnace tube hot spots; hydrogen attack on carbon steel; stress-corrosion of stainless steels, and a half-dozen other problems of varying magnitude.

Some typical instances of these problems were cited and the corrective measures discussed. It was a general opinion that the combination sulfur in the charge (calculated as H_2S) and the recycle gas should be below 0.006-0.01 percent by volume to minimize corrosion in low and intermediate alloy steel furnace tubes and transfer lines. Also, hydrogen seems to negate most of the protective nature of sulfide-containing scales, and the presence of hydrogen in major amounts must be considered when selecting metals for high temperature operations.

Stress-corrosion cracking of Type 304 stainless steel furnace tubes and transfer lines has been a problem for some. For example, one company had to replace eight stainless steel furnace tubes after only 1½ years of use. The excessive pitting was not attributable to sulfur corrosion, nor was the degree of carburization sufficient explanation. Similar problems have occurred in transfer lines. Possible cause: Stress corrosion cracking from polythionic acids formed by sulfide scale and moisture during turnarounds. Better fabrication and inspection techniques, stress relieving, and washing out with a five percent sodium carbonate solution after shutting down were all suggested as remedial procedures.

All were agreed that the most important factors in reformer corrosion were the concentration of H_2S in a hydrogen atmosphere and temperature. The austenitic stainless steels offer the greatest resistance to this type of corrosion, but special precautions must be taken to avoid corrosion and metal deterioration during shutdowns if 18-8 chromium-nickel steels are used.

Fouling, by itself or in combination with corrosion has been a headache, too. Its extent seem to be related to the dissolved oxygen content and sulfur compounds, usually occurs near the vaporization point, is not always cured by conventional means of eliminating oxygen.

Ultraformer Corrosion Control

Corrosion in Ultraformers can be checked by controlling the H_2S/H_2 ratio in vapor streams, by separating hydrogen-bearing and naphtha streams, by proper selection of alloys, and by injecting inhibitors. So say Andrew Dravnieks and C. H. Samans of Standard Oil Company (Indiana). One of the big problems is the deposition of sulfidic corrosion products in the catalyst beds, reducing the flow of vapors through the beds, and correspondingly raising the back pressures. For temperatures above 500 F 18-8 stainless steel serves well in exchanger tubes.

Another serviceable procedure is that of spray metallizing the surfaces of tubes, etc., with aluminum. The steel surface must be properly cleaned, and then blasted with sharp grit. After spraying on the molten coat it should be given a diffusion heat treatment at 1275-1300 F for one-half hour to improve the metal-to-metal bond.

Conditions and Causes of Reactor Failure

Study of the conditions and probable causes of failure of three reactors in Esso Standard's Baltimore, Maryland, Powerformer indicates conclusively that:

1. Cracking and failure is attributable to hydrogen attack;

2. Hydrogen attack occurred on a 201 steel in one year at hydrogen partial pressure of 330 psig, temperature of about 575 F, actual failure when metal temperatures of about 740 F prevailed;

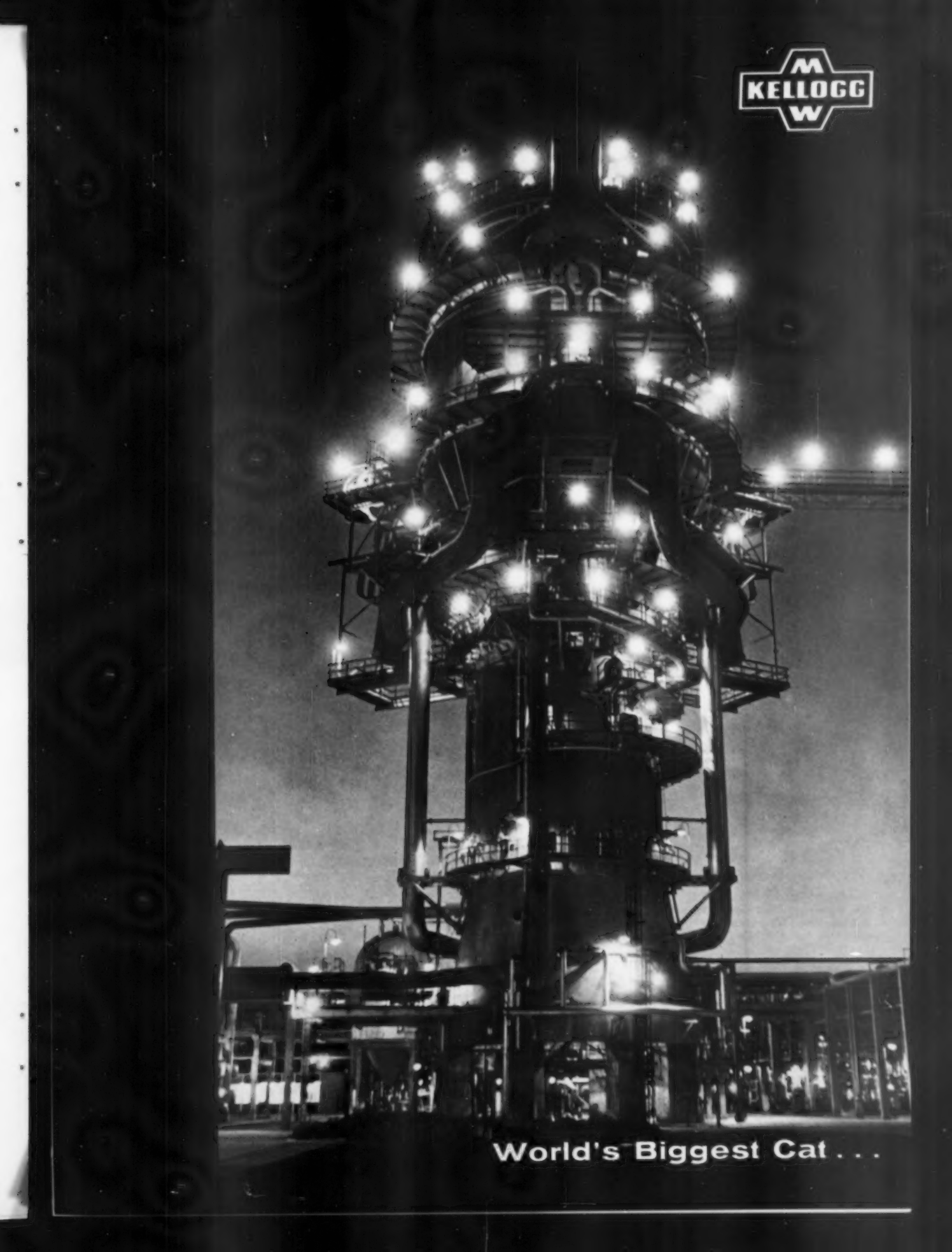
3. Hydrogen attack became more severe as temperature rose above 575 F. Hydrogen attack severity increases with rising temperature and with hydrogen partial pressure.

The attack occurs in three stages, generally: (1) Diffusion of atomic hydrogen into the steel; (2) Decarburization, and (3) Intergranular fissuring. Through the first stage steel undergoes a loss of ductility which is temporary, since it can be restored by a relatively low-temperature heat treatment. Permanent, irreversible embrittlement occurs when the attack has gone beyond the second and third stages.

Low pH Water Minimizes Corrosion in Crude Towers

Holding the pH of crude unit receiver waters to about 4.3, and with inhibitor injections of 10-15 ppm, a 27-month period of operation shows that after-effects have been eliminated and that equipment has been protected adequately. These are the conclusions reached by J. A. Biehl and E. A. Schnake of Ohio Oil Company's refining department.

As results of operating at these low pH values, and by increasing somewhat the inhibitor injection rates, these investigators find that the lower pH minimizes the ammonium-salt disassociation that otherwise contributes to the complex corrosion problems and the formation of copper and iron sulfides. No sludge deposits are present when these sulfides are not formed. ★ ★ ★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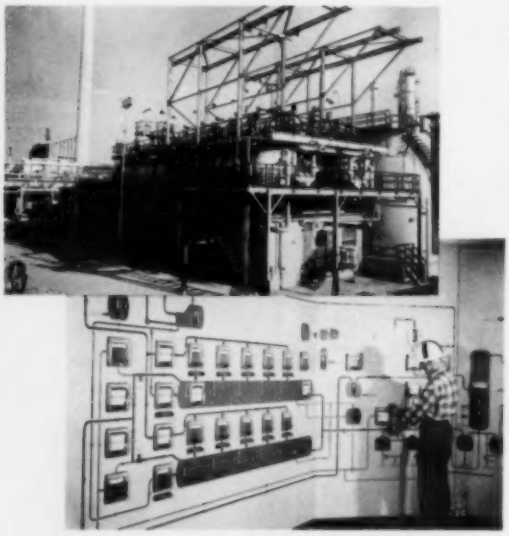
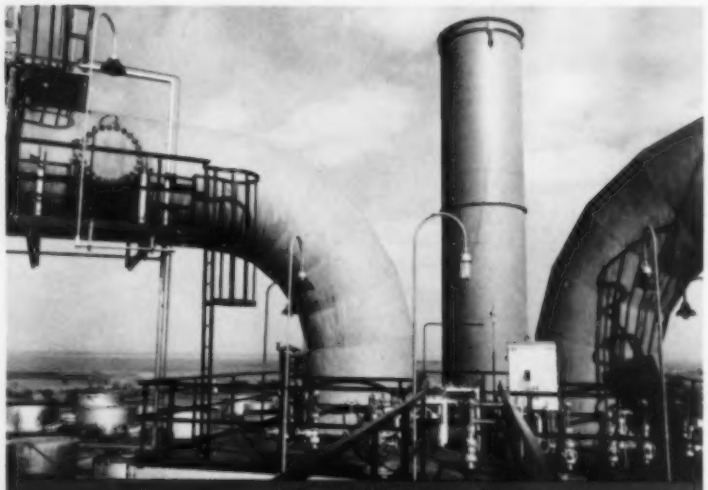
A throughput capacity of 102,000 BPD makes the Orthoflow Fluid Catalytic Cracking Unit, shown here and on the preceding page, the largest in the world. Engineered by The M. W. Kellogg Company for Tidewater Oil Company's Delaware Refinery, south of Wilmington, this Orthoflow is the culmination of Kellogg's experience in engineering 66 fluid catalytic cracking units throughout the world, of which 16 are Orthoflow units.

Kellogg welcomes the opportunity of demonstrating to other refiners, as it did for Tidewater, the numerous advantages of the Orthoflow design.

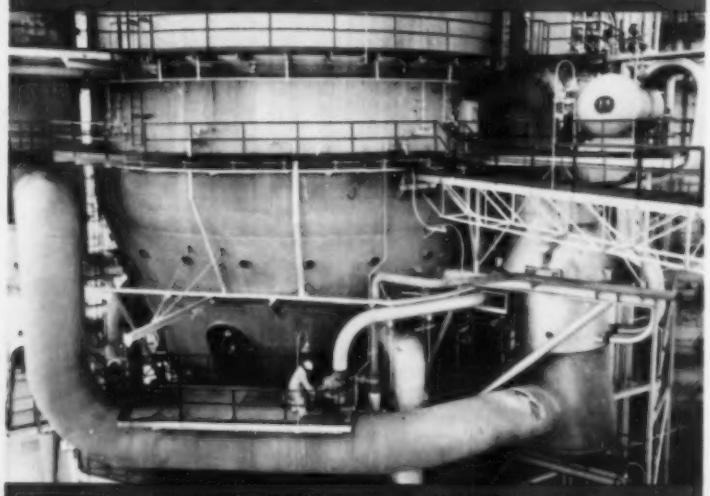


Kellogg Also Developed and Engineered Tidewater's Sulphuric Acid Alkylation Unit

With a design capacity of 5,000 BPD of alkylate, and a potential capacity of 9,000 BPD, Tidewater's alkylation unit at the Delaware Refinery is one of the largest in operation. Interior view shows controls for the two 5-stage reactors.



Atop Tidewater's Orthoflow Cat Cracker—25 stories high



Operator on platform of Orthoflow shows huge size of unit

Base of Orthoflow typifies its compact, functional design

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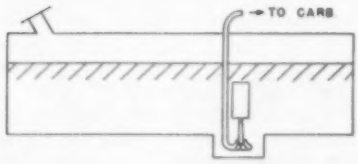
Vapor lock problem may be reduced greatly by placing pump in fuel tank; higher vapor pressure fuel may be permissible

Submerged Fuel Pumps Coming . . . . . Maybe

SOME cars in the near future may have their fuel pumps mounted inside or next to the fuel tank. The reason for moving the fuel pump from its present location on the engine to the rear of the car is simple — with all the power-driven auxiliaries now being put in the engine compartment, and with promises of even more, under-hood temperatures in the summertime may reach a point where there is danger of gasoline commencing to boil at the pump inlet. The pump then may no longer be able to supply sufficient fuel to the engine and the car may not run very well or perhaps not at all, a condition called vapor lock.

Du Pont's petroleum laboratory obtained and tested four of these new submerged fuel pumps from four manufacturers who are competing for this market. Fig. 1 shows how these pumps are mounted in a car fuel tank.

The pumps were tested on a 1956 Ford and 1956 Cadillac on a chassis dynamometer set for a 100 F day. The



Pump Make	Pump pressure, psig
1	7¼
2	3
3	5
4	4

FIG. 1. Fuel pump installed in a fuel tank.

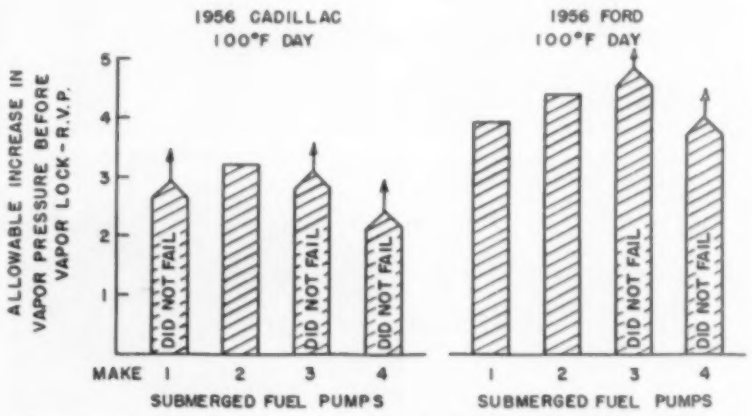


FIG. 2. Comparison of submerged pumps with standard pumps.

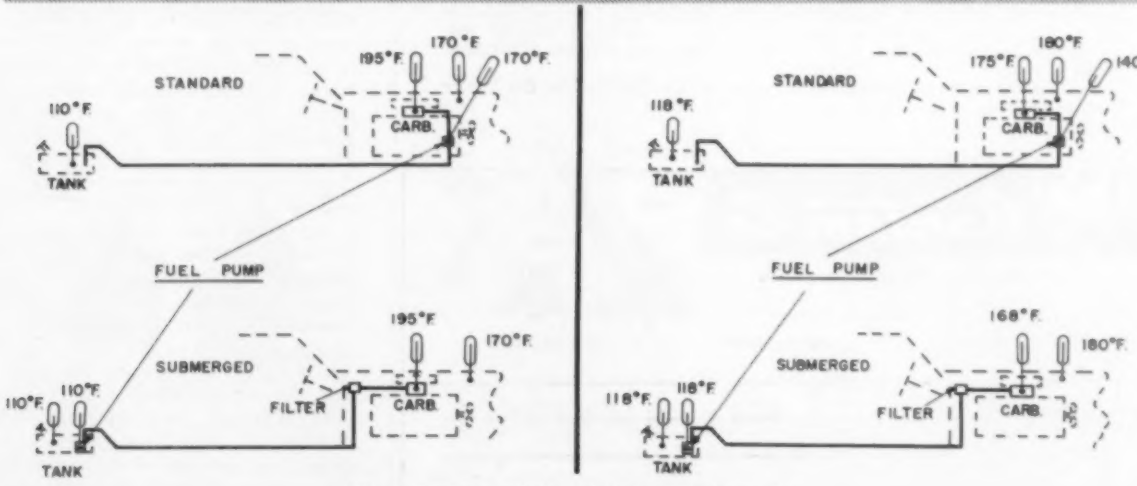
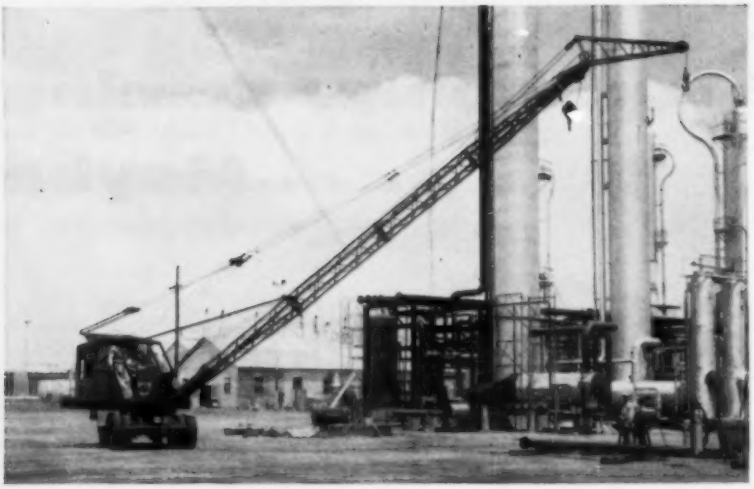


FIG. 3. Maximum vehicle and fuel system temperatures with submerged and with standard fuel pump installations.

Speedy **BANTAM**



- great "handy man"
- best for refinery construction and maintenance jobs

Whether it's trenching, backfilling, erecting steel, cleaning ditches, digging sump pump holes, installing or handling pipe—on dozens of tasks around refineries—the versatile, fast-moving BANTAM is your most efficient, low-cost rig.

High mobility on crane carrier mounting means that you can go anywhere—fast. Nine different quick-change attachments mean you can answer practically any need for digging—or for lifting loads of 6 and 7 tons. As a crane it gives you safe, precise handling with the ability to "inch" loads into position. Boom lengths available up to 45 feet; power up boom and power controlled lowering is standard.

Refinery users tell us that BANTAM works many places where other rigs can't go. Yet, with all its multi-purpose uses, BANTAM's low cost makes it the most competitive rig on the market. It not only costs less to buy, but less to operate, less to maintain. And it's reliable—the most job-proved machine of its kind.

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SCHIELD Bantam Co.

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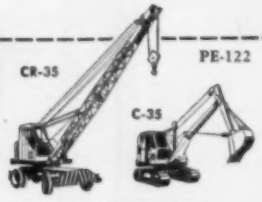

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WORLD'S LARGEST PRODUCER OF TRUCK CRANES AND EXCAVATORS

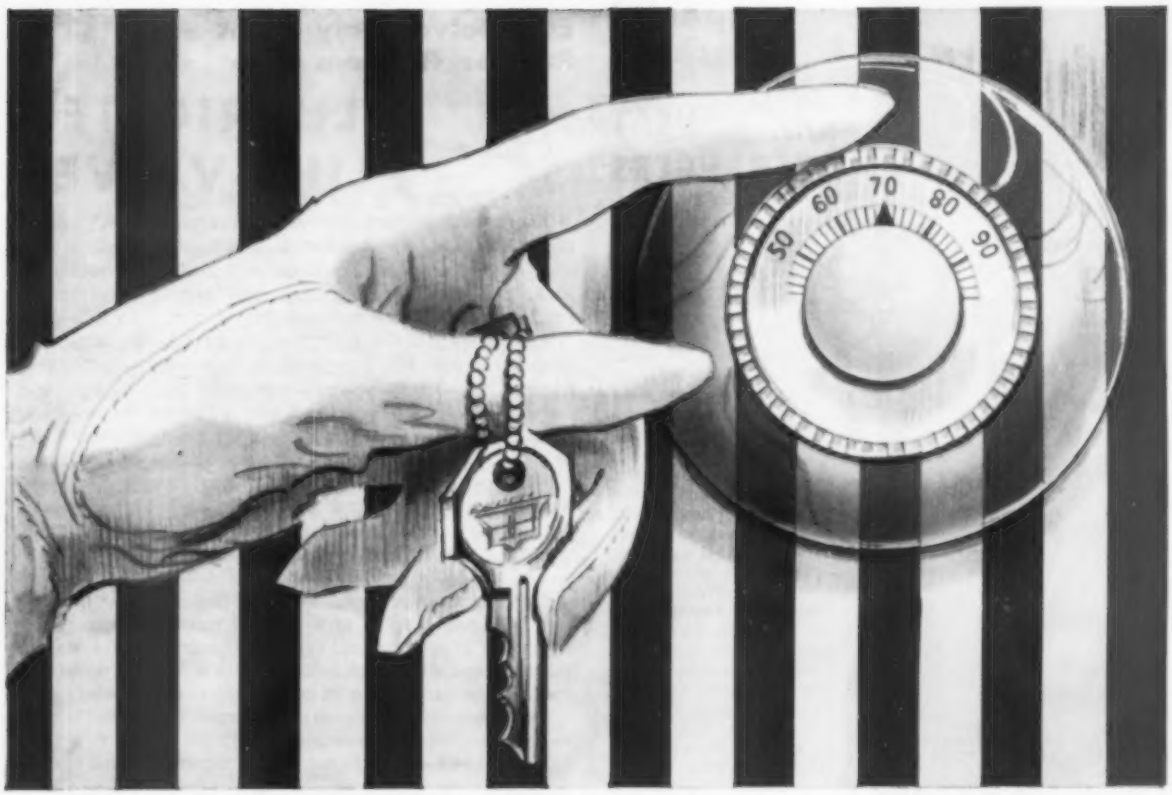
cars were driven for one hour and a half at 60 mph, simulating turnpike driving, followed by five minutes of idle. The heat stored in the engine from this high speed driving was then allowed to soak into the fuel system during a 10-min shutdown. Following this soak period the car was restarted and accelerated to 60 mph. The relative performance of the pumps was measured by operating on a commercial fuel whose vapor-forming tendency was gradually increased by stepwise additions of butane. When vapor lock occurred the vapor pressure of the blend in use was considered to be the limit of the pump. Some of the pumps had a capacity which exceeded the highest vapor pressure of any practical blend which could be used on a 100 F day.

This study has shown that these pumps will keep a car operating smoothly at under-hood temperatures as much as 20 to 40 F higher than with current engine-mounted pumps. This corresponds to an increase of 3 to 4 lb in the Reid vapor pressure limit of the gasoline as illustrated in Fig. 2.

In the cases where vapor lock was experienced, the restricting formation of vapor occurred at the pump inlet for the conventional diaphragm pumps; for the submerged pumps the restriction occurred at the fuel filter placed on the engine compartment firewall just ahead of the carburetor.

The superior performance of the submerged pumps is due primarily to the more favorable temperature conditions existing at the pump inlet, temperatures being as much as 65 F lower. Carburetor bowl temperature reached a maximum of 195 F — this is high enough to cause boiling in the carburetor with present-day fuels and explains why occasionally a car will be difficult to restart when hot. The temperatures shown are the maximums following the soak period. However, for steady-load turnpike driving, 60 mph, temperatures in the fuel system are in 120-130 F range. This explains why vapor lock usually does not occur until the engine is idled, or shutdown, following a high-speed run on pulling a grade. Typical temperatures measured in the two cars are shown in Fig. 3.

Increasing vapor pressure means increased yields, octane numbers and profits to the petroleum industry but it also brings serious problems to the automotive industry. Submerged fuel pumps appear to be one small step in the direction of designing the car so that higher vapor pressure fuels can be used. However, other problems, such as vapor loss of fuel from the car tank, safety, and a number of design difficulties remain. Progress, therefore, will be gradual. * * *



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a heating oil sales feature that can make you extra profits... save you money... increase customer satisfaction

In today's highly competitive fuel oil market, you can gain three distinct advantages by using Du Pont Fuel Oil Additive No. 2 (FOA-2):

1. Win new customers
2. Save money on expensive contract service calls
3. Increase customer satisfaction

Here's why

FOA-2 contributes to clean burning by minimizing deposits in fuel systems. So, by advertising and promoting oils that will stay clean, you will attract new customers who are tired of oil that causes stoppages.

Sludge-free furnace oil means no clogging of filters, strainers, nozzles and other burner parts. Burners stay in adjustment longer and fewer service calls are required.

Dispersant action

Du Pont FOA-2 is also a dispersant and solubilizer. Over a period of time, it reduces pre-formed deposits throughout entire systems.

Ashless

FOA-2 burns completely, without leaving any ash to interfere with the operation of ignition and stack controls. Because of this, it helps reduce chimney deposits and the possibility of puff-backs.

For best results, Du Pont FOA-2 should be added to freshly prepared stocks *at the refinery*. Small amounts are enough to protect most stocks from sludge... insure cleaner burning... reduce deposits in heating systems... prevent nozzle and filter fouling... and *keep* the systems clean.

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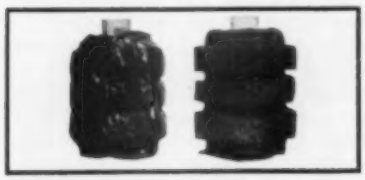

Just look at the difference! Filter on left was used for 90 days with untreated fuel. Filter on right was used for 90 days with same fuel to which FOA-2 had been added.

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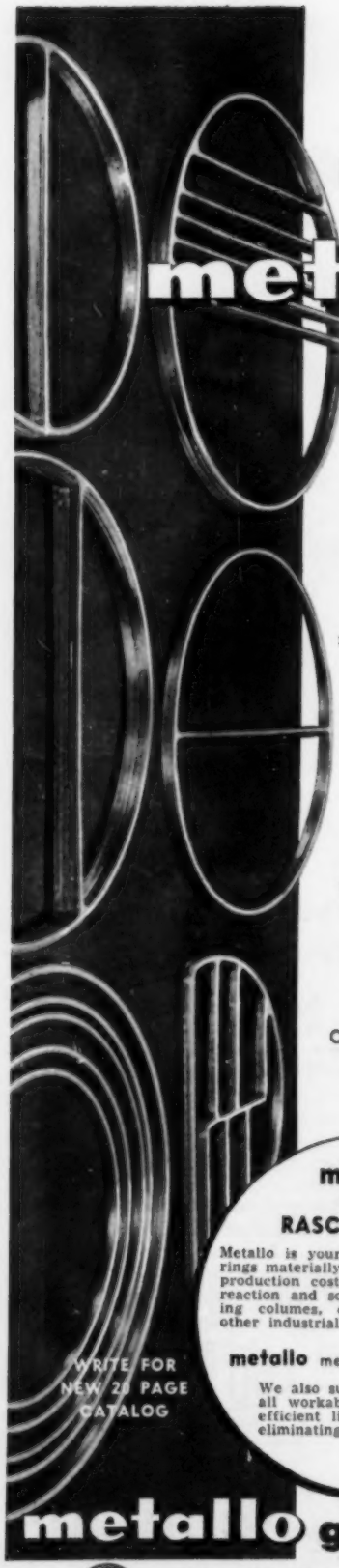

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Metallo is your primary source. These rings materially decrease operating and production costs on a wide variety of reaction and scrubbing towers, rectifying columns, extraction systems and other industrial processes.

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We also supply Lessig rings in all workable metals to act as efficient liquid distributors by eliminating cross flows.

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Heat Exchangers, Raschig Rings, Lessig Rings, Gaskets, Valve Discs and Metal Stampings

Esso Solves Poly Plant Reactor Problem with

LUBRICATED PLUG VALVES

The valving problem involved in controlling flow through polymerization plant reactors is well known. Leakage and eventual valve failure are common, caused by continuous high pressures, corrosive fluids, and minute quantities of reactor catalyst in the outlet stream.

Esso Standard Oil Company, faced recently with this situation at the No. 2 poly plant at its Bayway refinery, Linden, New Jersey, solved the problem by installing lubricated plug valves on inlet and outlet lines to the reactors. In this type of valve, seating surfaces are removed from the line of flow and the valve core is a strong tapered steel plug.

After more than six months of normal reactor operation, Bayway operators report that leakage is no longer a problem. None of the operating valves shows signs of wear, and maintenance problems have been reduced.

Esso's No. 2 poly plant, a unit of the C-3 type erected in 1954, utilizes 12 reactors. The feed leaves the pumps in a 4-in. line which splits to 3-in. inlet manifold headers for each bank of six reactors. From the headers, 3-in. lines are taken off to each pair of reactors, with a 3-in. valve used at each line to throttle flow to assure even reactor feed.

Downstream of the valve, the line splits and feeds through two 2-in. valves to each single reactor. The first valve is used only as a block valve, the second is a throttling valve to continue the even feed process. Meters at the throttling valves are used to give visual indication of rate of flow to each meter.

Variety of Valve Services

Valves are subjected to extensive throttling as well as to shut-off service. One valve may be cracked as often as six times a shift, while another may remain in the full-open position for long periods of time. When valves are closed, however, as in reactor turnaround, they must be capable of tight, positive shut-off, without galling or seizing. It is this variety of valve services, as well as the continuous high pressures and temperatures, which makes poly plant reactor valving a problem.

At Bayway, leakage initially developed from minute quantities of catalyst in the outlet stream lodging in the seats of valves on the outlet manifold, impairing their shut-off qualities.

Esso installed the first lubricating plug valves in October 1955, on a test basis. Further valves were installed in January 1956, and on the basis of past performance (in which maintenance was reduced and valves taken off the line and inspected showed no signs of scoring or pitting) the reactor section was equipped with additional lubricated plug valves in June 1956. In all, approximately 115 Rockwell-Nordstrom Hypreseal valves, 1 to 3-in. in size, were installed.

Successful application of the valves to the reactor unit was largely a function of lubricated plug valve design. Of strong, simple construction, this type of valve comprises only three basic parts: Body, cover and plug. The tapered steel plug is the only movable member, rotating on a lubricated seating surface. The plug is of sufficient diameter to withstand continuous reactor pressures, and fluid flow, directed through ports in the plug cannot reach the protected valve seat to damage the surface.

Bayway operators report that a simple program of periodic lubrication, done while the valves are in service, is all that is necessary to maintain the lubricated plugs in good condition.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Sharp Trends in Refinery Electric power

Utilization

Refiners are using more electricity than ever before . . . and, not only due to mere expansion of refining capacity. During the past 25 years, refining capacity has grown 250 percent. Connected electric horsepower has grown about 325 percent during the same period, now totals about 3,200,000 hp!

G. H. Hill, of Cities Service Refining Corporation, Lake Charles, Louisiana, cited these and other figures to a recent Petroleum Electric Power Association meeting in Amarillo to point up the trend towards increasing use of purchased power.

ity plays a big part, too. Catalytic conversion processes make gas that has to be compressed ahead of recovery facilities. And many of these gases are no longer used to fuel boilers that, in turn, generate steam to drive turbine-type drivers—they are being diverted to petrochemicals manufacture instead. Hill claims the changes in refinery operations has "resulted in increased horsepower, with a decrease in steam requirements, and has resulted in economic balance favoring power drives."

The following breakdown is taken from charts that Hill had prepared:

	—1940—	—1945—	—1950—	—1955—
Total Conn. Hp	1,250,000	2,000,000	2,625,000	3,200,000
Purchased Power, Percent	60	65	70	75
KWHr/Barrel of Capacity	2.3	3.2	3.6	4.0

Hill pointed out that the growth in demand is not only due to mere increase in refining capacity. Complex-

A little mental arithmetic reveals that purchased power has provided very nearly 85 percent of the increased power demands by refiners since 1940. And, since 1945, growth is purchased power—about 1,300,000 connected hp—has exceeded growth in total refinery horsepower by 100,000 connected hp. In other words, refineries are shutting down some of their generating stations in favor of purchased power.

Indicative of this is the new Public Service Gas & Electric Company station in Bayway, New Jersey. Recently "on-stream," the plant supplies almost all power requirements to Esso Standard's sprawling Bayway refinery, replacing the refinery power stations. Two of the country's newest refineries are using purchased power, too. At both the Tidewater Oil Company refinery in Delaware City, Delaware, and American Oil Company's new plant in Yorktown, Virginia, separately owned power stations adjacent to the refineries provide all electricity and most steam requirements.

Why is there such a trend? There are several answers, almost all of them correct. "We're in the refining business, not the power generating business," claimed a refinery superintendent recently. Another official pointed out that, in many cases, purchased power is significantly less expensive.

Another key factor: Investment. Fewer dollars put into power and steam facilities means more money for process facilities, etc.

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Heat and vibration-proof, non-solvent, will not shrink, crack or crumble. Makes all assemblies leak-proof and pressure-tight. Prevents rust, corrosion, joint seizure.

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The super-penetrating rust solvent

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SAFETY CONTROLS

For

PRESSURE
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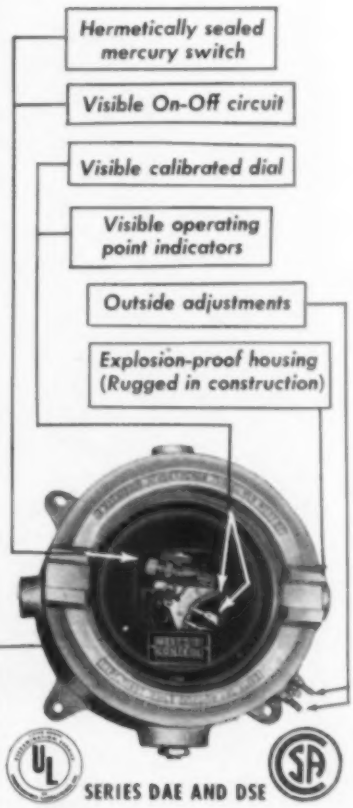

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Built to last the life of the equipment it serves

Our engineers are at your service —send in your control problem.

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PETROCHEMICALS

another broad field for UOP service to oil refiners . . .

In its business of developing improved refining processes for the oil industry, Universal Oil Products Company has long been vitally concerned with effective means of producing the valuable chemical products from petroleum. The great worth of these petrochemicals to our national economy is recognized by everyone. They are vitally important to the refining industry, too, if refiners are to maximize the value of products from crude oil processed through their plants.

In the interest of the oil refining industry UOP has recently established a program of petrochemical process and marketing development. Under this program any refiner, anywhere in the free world, regardless of the volume of his operation will be able to enjoy the economic and operating advantages which the production of the petrochemicals most suited to this operation can provide.

This new petrochemical program makes available to you, through UOP, a variety of petrochemical processes.

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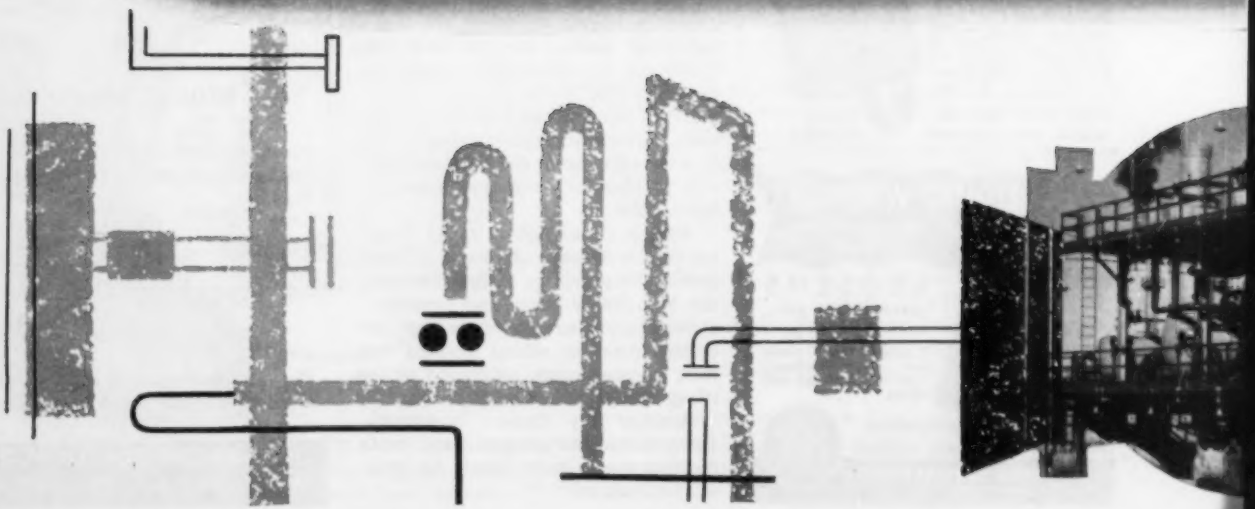
More Than Forty Years Of Leadership In Petroleum Refining Technology



NEW Refining Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Actuator Does Man-Size Job. The complete Oil-Dyne unit used to actuate a 12 in. gate valve — pump, pressure switch, cylinder, reservoir and motor—is actually dwarfed by the size of the valve itself. Yet this compact, power-packed hydraulic unit actually does the same job as a far more expensive electrically-driven gear motor. Due to the tapered wedge and seat found in gate valves, greater pressure is normally needed to open the valve than to close it, particularly if the valve has been closed for some time. On one Oil-Dyne valve application, a closing pressure range of 2000 psi is provided on one side of the cylinder, and an opening pressure range of 3000 psi is provided on the other side. Any combination of 50 to 5000 psi could be provided. *Oil Dyne, Inc.*

Circle number (41) on reply card.

Coating Provides New Pipe Life. An amazing increase in service life for tubing and pipe subjected to highly corrosive agents in oil refinery and petrochemical plant piping systems and heat transfer equipment is available in the form of "Niphos" nickel alloy coatings. After application, the coating is fused by heating in a reducing atmosphere, into a protective nickel alloy cladding. The coating, or cladding, actually forms an interface with the base metal, adhering to it so tenaciously that no evidence of flaking, peeling or exfoliation is encountered, even after 180-deg bends, so often required in return-bend heat exchanger tubing, are formed of the treated units. *Tube Reducing Corporation.*

Circle number (42) on reply card.

Build Tanks Within Tanks. Tanks within tanks. This is one of the latest fabricating innovations of Haveg Industries. By using newly developed techniques, Haveg can convert worthless old tanks into usable systems.

The tank-lining resin plastics employed are asbestos filled phenolic or furan, graphite filled epoxy, and glass reinforced polyester. These materials of construction will resist nearly all commercially encountered chemicals including acids (even hydrofluoric), alkalis, and most organic liquids.

The lining of tanks by field molding or cementing can mean substantial savings because (1) the cost of the tank is less, (2) the need for razing the original tank is eliminated, and (3) where tanks are inside buildings, there is no need to make changes in the building's structure to permit the entry or removal of large tanks. Tanks up to 55 ft in diameter have been lined. *Haveg Industries, Inc.*

Circle number (43) on reply card.

Platform Truck Handles 2 Tons. Completely new "Freighter" platform truck is designed to transport loads of up to 4000 lb safely and rapidly through confined aisles and crowded areas of terminals and warehouses. It is powered by Wisconsin's industrial Model AEN engine and has fully automatic drive, which results in smooth power flow and excellent "inching" qualities for precise load positioning.

The air-cooled engine provides 8.1 hp at 3000 rpm for ample power to negotiate ramps up to 10 percent with full load. The "Freighter" can be operated at speeds up to 10 mph and is reported to be extremely economical in operation. Simplified driving controls make the "Freighter" unusually easy to operate. *Hyster Company.*

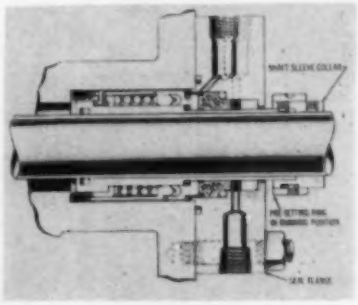
Circle number (44) on reply card.

Giant Size Column Redistributors. After several years of field testing, Distillation Engineering announces the successful completion of their giant size packed column redistributors. Sizes up to 6 ft 6 in. in diameter, have been performance-tested with packing such as Raschig rings, Berl saddles, Intalox saddles, and Protruded packing. These units show improvement in column plate efficiency of 100 percent, in most cases.

These redistributors now make it possible to utilize the economy and low pressure drop of large diameter packed columns, while obtaining the separating efficiency which had previously been lacking. This patented unit collects the liquid which tends to run down the column wall in an annular ring and distributes it evenly, by means of vanes, across the packing. A certain portion of the liquid is intercepted by the vanes themselves, thus equalizing still further the distribution. *Distillation Engineering Company.*

Circle number (45) on reply card.

Pre-Setting Ring Feature Seals. Perfect mechanical seal installation without measurement is now "built in" with the new Byron Jackson exclusive pre-setting ring feature. Anyone with simple hand tools now can perfectly install or replace BJ mechanical seals with pre-setting ring without taking measurements or referring to installation drawings.



This new development provides a seal assembled as a cartridge unit ready for installation. No field fitting is required. The BJ pre-setting ring is attached to the shaft sleeve collar with a set-screw in a slot of controlled length. Seal users benefit from installation time savings and greatly reduced downtime on periodic pump inspections. *Byron Jackson Pumps, Incorporated.*

Circle number (46) on reply card.

Blower Operates at 73,000 rpm. New, small, high speed axial blower is suitable for applications requiring cooling air for electronic or electrical power equipment. The Model 111 blower operates at 73,000 rpm with a corresponding decrease in weight over conventional blowers. Delivery is 95 cu ft per min with a pressure rise of 10 in. of water. Measuring only 13⅜ in. by 9 in., the unit is equipped with a pneumatically operated by-pass valve which opens when not running. *Propulsion Research Corporation.*

Circle number (47) on reply card.

Flying Spot Microscope. A television type technique used as a substitute for human vision in microscope studies, which allows precision analyses and measurements of approximately 1 million particles per sec, was demonstrated. It was pointed out that a human is limited to handling approximately 40 bits of information per minute. The "flying spot" microscope utilizes television principles to scan microscopic specimens. System will make possible studies in microscopy never before undertaken because of the inaccuracies due to human error and the spectral and other limitations of the eye.

The "flying spot" microscope incorporates standard and conventional microscope optics, but the light source, instead of being the usual evenly illuminated plane, is a rapidly moving spot of light. This spot, produced electronically by a beam of electrons inside a cathode-ray tube, is rapidly deflected by electrical techniques similar to those used in television. *Allen B. Du Mont Laboratories, Inc.*

Circle number (48) on reply card.

The biggest mistake is the one you can't see!

As an experienced pipeline man, you'll have little trouble spotting four obvious "errors" in this picture*. But the *biggest* and most *costly* error you can make in pipeline construction is to gamble on unproven or "economy" types of pipeline protection.

Sure, you can buy "protection" that will save you a few first-cost dollars. But wait until you start paying the bills for excessive cathodic protection!

On line after line, in marshlands and mountains, tough, durable *Pitt Chem* Coal Tar Enamels have *proved* their superior ability to resist soil stress and water absorption, the two pitfalls of "economy" coatings. It's the kind of protection that gives you maximum insurance against high maintenance cost.

When you specify *Pitt Chem* you get assured quality, for *Pitt Chem* Coal Tar Enamels are manufactured to rigid, *published* specifications, from highest grade materials.

How can we help you! Send us the details of your coating problem.

*Operating from left side of ditch; man standing on line; man in ditch under line traveling machine; loop in "Hoosier" pole.

PITT CHEM® TAR BASE ENAMELS

- Standard Grade
- Modified Grade
- Plasticized Grade
- Hotline
- Cold Applied Tar Base Coatings

WBW 6587

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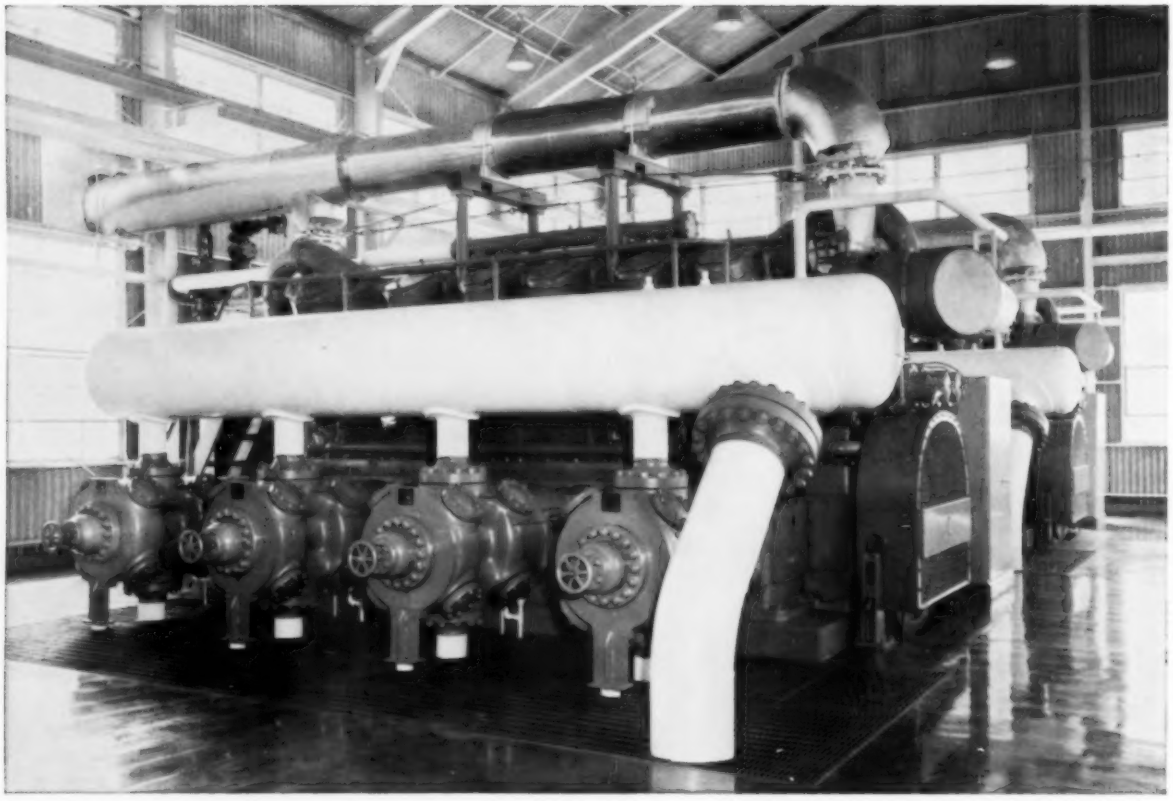

At Shelbyville, Indiana

American Louisiana installs 10,000 hp of KVS turbocharged gas-engine compressors

At Shelbyville, Indiana, in one of the three primary stations of American Louisiana Pipe Line Company, the efficiency of Ingersoll-Rand compressors and the flexibility of 4-cycle power are being applied to the task of supplying gas to utilities in Michigan, Wisconsin, Iowa and Missouri.

All of the five gas compressors at the Shelbyville station are 2000-hp Ingersoll-Rand KVS turbocharged gas-engine units. These are basically the same machines which have been setting new records since the first KVS was installed early in 1952, but incorporating the improvements which have resulted from years of tough service.

Incidentally, the first KVS (and the world's first turbocharged engine-compressor) was installed for an American Louisiana affiliate. With the forthcoming installation of six units at its new Defiance (Ohio) station, American Louisiana and affiliates will be operating 23 KVS compressors totalling 44,000 hp.

In addition to heavy-duty compressors, Ingersoll-Rand equipment for pipeline services includes rugged 4-cycle V-angle engine-generating units, centrifugal pumps, starting-air compressors, air and electric Impactools, and many other products. Ask your I-R representative how I-R can help you on your job.

Only Compressors have CHANNEL VALVES

Known for high efficiency, quiet operation and exceptional durability. Entirely different. Each valve is a combination of rigid stainless-steel channels and leaf springs, with trapped-air spaces which cushion action.

Ingersoll-Rand 4-CYCLE

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COMPRESSORS • GAS AND DIESEL ENGINES • ROCK DRILLS • PUMPS • TURBO-BLOWERS • AIR AND ELECTRIC TOOLS

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

PIPELINE DEVELOPMENTS ★ ★ ★

Roundup of Planned and Proposed Construction

The following tables list the company, mileage, pipe size, and location of proposed pipeline projects — crude, products, and natural gas — reported to *The Pipeline Engineer*. Company addresses are given when known.

CRUDE LINES

Name of Company	Miles	Size	Location
Act Oils, Toronto, Ontario	350	—	Line from Peace River area in British Columbia, thru Pine Pass to Prince George, westward to Bella Coola terminus on Pacific Coast
Atlantic-Cities-Service-Continental-Gulf-Phillips-Texas-Sinclair	Approx 385	26	Midland, Texas, area to Houston
Cape Pipe Line Company Philadelphia, Pennsylvania	200	—	Large diameter from Delaware Bay to Greater Philadelphia area refineries
Lakehead Pipe Line Company, Inc. Toronto 1, Ontario, Canada	80	26	Loop from Clearbrook, Minnesota, to Superior, Wisconsin
Oil Field Pipe Line, Inc. Wichita, Kansas	—	8	To extend northeast from Hugoton field, Kansas, to Raymond, Kansas tie-in with Arapahoe Pipe Line system
Muskegon Pipe Line Corporation Muskegon, Michigan	165	10	Griffith, Indiana to Muskegon, Michigan to supply Aurora and Naph-Sol refineries
North-West Oil Pipelines Company	210	—	Wilhelmshaven, on the North Sea, to industrial Ruhr area of West Germany
Northwest Pipe Line Corporation Salt Lake City, Utah	350	8–10	Four Corners area to Salt Lake City, Utah
Offshore Gathering Company Houston, Texas	364	20	Gulf of Mexico from Sabine Pass to Mississippi River
Royal Dutch Shell Group and Others The Hague, Netherlands	870	30	Marseille, France, to Rotterdam, Holland, and Antwerp, Belgium
Royal Pipe Lines, Ltd. Regina, Saskatchewan, Canada	288	Var.	Cantuar area fields to Glenavon
Salt Lake Pipe Line Company Salt Lake City, Utah	100	10	Additions to Rangely, Colorado-Salt Lake City line
Seventeen American, British, French and Dutch companies	—	38–40	Likely route to run from head of Persian Gulf, through Iraq and Turkey to Turkish coast on the Mediterranean Sea
Sinclair Pipe Line Company Independence, Kansas	150	20	Teague to Houston, Texas
Southern Kansas Pipe Line Company	310	6, 10	10,000 bbl per day line from Greenwood pool, near Colorado line, thru Liberal to Arkansas City, Kansas
Texas-New Mexico Pipe Line Company Houston, Texas	515	16	Extension from Jal, New Mexico, pump station to Four Corners area
Trans-Border Pipe Line Company	110	—	Skagway, Alaska, to Whitehorse, Yukon Territory

PRODUCTS LINES

Name of Company	Miles	Size	Location
Buckeye Pipe Line Company	70	8	Wayne to Durand, Michigan, common carrier
Equitable Gas Company and Subsidiaries Pittsburgh, Pennsylvania	100	4–5	Maytown, Kentucky, to Institute, West Virginia
Laurel Pipe Line Company Pittsburgh, Pennsylvania	440	14–24	Philadelphia to Pittsburgh to Cleveland
Northwest Pipeline Corporation Salt Lake City, Utah	350	8–10	Four Corners to Salt Lake City, Utah
Ohio Oil Company	—	—	Common carrier line from Wood River, Illinois, to Chicago
Findlay, Ohio	—	—	Connecting line from Robinson, Illinois, refinery to new line
Salt Lake Pipe Line Company Salt Lake City, Utah	80	8	Additions to Boise, Idaho, to Pasco, Washington, line
Service-Continental-Sinclair-Phillips	550	—	Salt Lake City, Utah, to Spokane, Washington
Texas Eastern Transmission Corporation Shreveport, Louisiana	1168	16–20	Conversion of "Little Inch" between Beaumont, Texas, and Moundsville, West Virginia
Union Oil Company of California	815	—	Shale Oil Plant, Rifle, Colorado, to Los Angeles area
Winnipeg & Central Gas Company Winnipeg, Manitoba, Canada	210	6	U. S.-Canadian border to Winnipeg

for cooling tower application...

There's MORE protection against humidity in Allis-Chalmers MOTORS

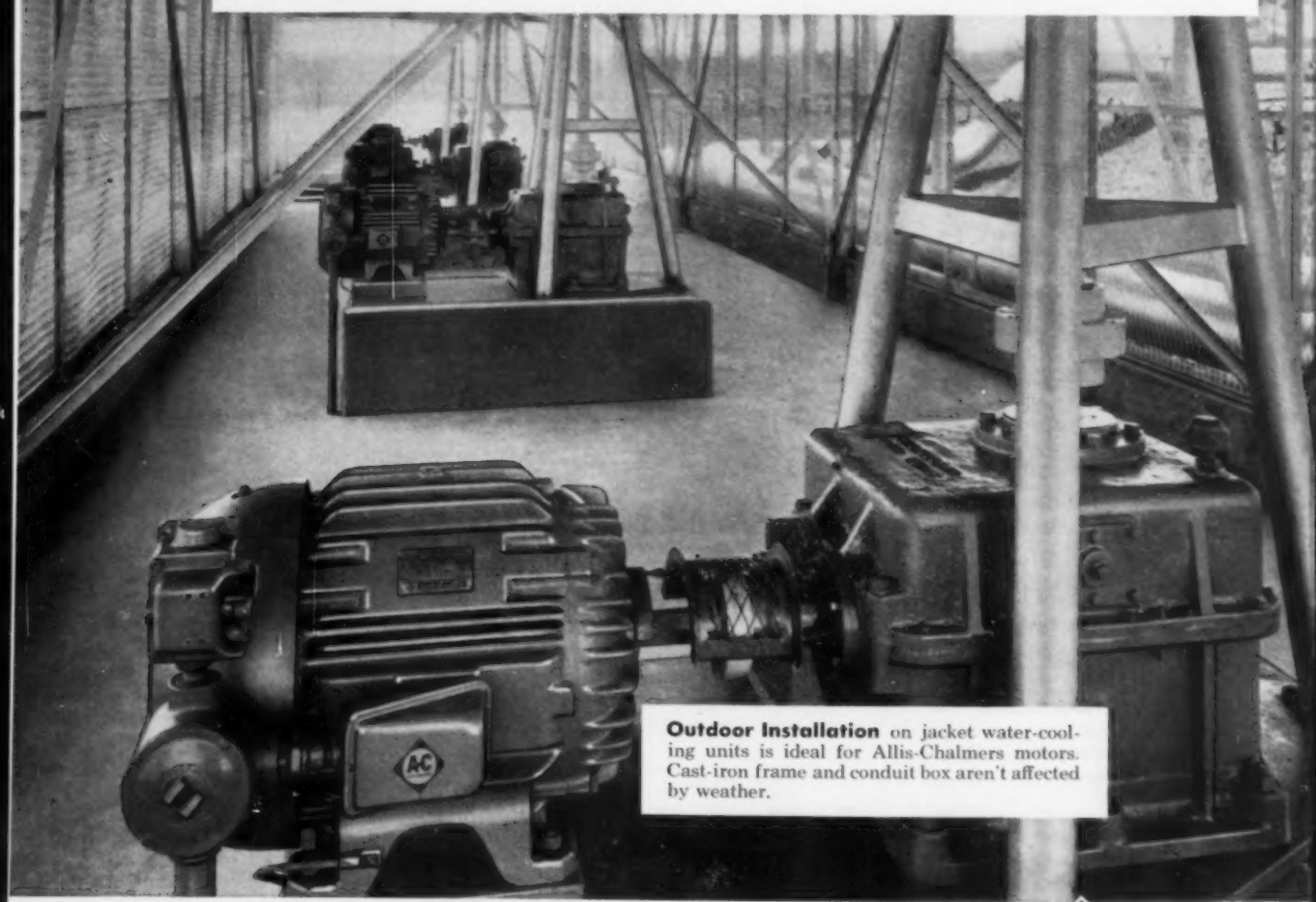
The ultimate in protection against high humidity — major cause of cooling tower motor failure — is provided tower builders and users in Allis-Chalmers TEFC motors. Here's why:

1. **Moisture drainage** — Drain plug can be removed to eliminate condensed moisture in the motor. (Particularly helpful in intermittent operations where condensation is more likely.)

2. **Extra-insulated stator** — Several applications of special insulating varnish plus repeated baking keep humidity out . . . give the long electrical life you need.

3. **Weather-protected bearings** — Rotating seal, turning in close running clearances, guards against entry of water.

Find out more about the "MORE" in Allis-Chalmers motors by contacting your nearby A-C sales office or distributor, or write Allis-Chalmers, General Products Division, Milwaukee 1, Wis.



Outdoor Installation on jacket water-cooling units is ideal for Allis-Chalmers motors. Cast-iron frame and conduit box aren't affected by weather.

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

A-5183

ARMCO WELDED STEEL PIPE SAVES YOU MONEY 3 WAYS

LONG, UNIFORM LENGTHS

Uniform lengths, up to 50 feet without a circumferential weld, mean fewer joints, faster assembly, and easy, accurate computation of joints required.

CHOICE OF 20 DIAMETERS

Wide range of diameters makes it unnecessary to buy more capacity than is needed.

CHOICE OF 10 WALL THICKNESSES

You can select the correct wall thickness for the job without buying costly excess metal.

* * * *

Write for more data. Armco Drainage & Metal Products, Inc., Welded Pipe Sales Division, 4847 Curtis Street, Middletown, Ohio. 201 KOME Building, Tulsa, Oklahoma. Subsidiary of Armco Steel Corporation. Export: The Armco International Corporation.

Where Armco Pipe is used in the Oil and Gas Industries

1. **Natural Gas and Natural Gasoline Divisions**
   a. Gas gathering lines
   b. Natural gasoline plant piping
   c. Residue gas lines
   d. Gas transmission lines
2. **Oil Refining Division**
   a. Stock lines
   b. Low pressure steam lines
   c. Vapor collection lines
   d. Waste product lines
3. **Oil Producing Division**
   a. Casing
   b. Oil lines
4. **Miscellaneous uses (all divisions)**
   a. Conduit or casing pipe
   b. Pipe piles, pile shells
   c. Water well casing
   d. Water supply lines
   e. Cooling water systems

ARMCO WELDED STEEL PIPE

GAS LINES

Name of Company	Miles	Size	Location
Arkansas Louisiana Gas Company	300	—	Main and gathering lines Louisiana-Texas Gulf Coast
Andes Pipeline Corporation	500	12	Villamontes, Bolivia, to Antofagasta, Chile
Cities Service Oil Company Bartlesville, Oklahoma	70	—	Gas gathering system on the Roberts Ranch, Midland, Texas
Coastal Transmission Corporation	574	22–26	McAllen, Texas, to Baton Rouge, Louisiana
Dallas, Texas	414	Var.	Gathering lines in Rio Grande Valley, Texas
Colorado Interstate Gas Company	345	30	Kit Carson, Colorado, to Beatrice, Nebraska
Colorado Springs, Colorado	100	24	Springfield to Pueblo, Colorado
	24	24	Greenwood to Panhandle-Kit Carson loop
	109	26	Loop from Fourway, Texas, to Springfield, Colorado
	66	30	Loop from Springfield to Kit Carson, Colorado
	10	16	Keyes field, Oklahoma, to mainline
	6	10	Tablerock field, Wyoming, to mainline
	12.0	12–24	Additions in Texas Panhandle fields
	50	22	Mocane field, to Hooker, Oklahoma
Eastern Shore Natural Gas Company Salisbury, Maryland	124	6, 8	Transmission line and facilities in Delaware and Maryland
Kansas-Nebraska Natural Gas Company	61.3	Var.	Gathering lines from Camerick field to Liberal, Kansas
Phillipsburg, Kansas	10	10	Grand Island to Fullerton, Nebraska
	10	8	Loop from Grand Island to Fullerton, Nebraska
	11.5	12	Replacement from Scott City to Oakley, Kansas
	1.2	6	Additions to system in Nebraska
	9	8	Lexington to Central Nebraska Public Power Electric Plant
	14	16	Replacement from North Platte to Maxwell, Nebraska
Midwestern Gas Transmission Company	1112	12–24	Mainline from U. S. Canadian border near Emerson, Manitoba — Noyes, Minnesota, to Portland, Tennessee
	648	3–18	Laterals of mainline to serve communities in Minnesota, North Dakota, and Wisconsin
Natural Gas Pipe Line Company of America	38	36	Joliet to Elgin, Illinois
Chicago, Illinois	405	36	Beaver County, Oklahoma, to Joliet, Illinois (loops)
	25	—	Gathering line from Quinduna field, Roberts County, Texas, to point on existing line
	91	30	Loops in Nebraska, Kansas, Oklahoma
	337	30	Looping between Texas terminus and Beatrice, Nebraska
Northern Natural Gas Company	28	24	Ogden to Redfield storage area, Iowa
Omaha, Nebraska	168	20	St. Paul-Minnesota to Duluth, Minnesota, and Superior, Wisconsin
	100	20–24	Savannah Creek field, Alberta, to Alberta-Montana border near Cardston, Alberta
Northern Plains Natural Gas Company (subsidiary of Northern Natural Gas Company) Omaha, Nebraska	1100	26	Alberta-Montana border to Minneapolis, Minnesota
Offshore Gathering Company Houston, Texas	364	30	Offshore gas line in Gulf of Mexico from Sabine Pass to Mississippi River
Ohio Fuel Gas Company, Columbus, Ohio	37.7	24	Parallel line from Crawford station, to station in Licking County, Ohio
	17.2	20	Extend line from Jackson County terminus to station in Lawrence County, Ohio
Pacific Gas & Electric Company	200	12	Glenn and Tehama counties to Eureka and Arcata, California
San Francisco, California	502	34	Loop existing system in California
Pacific Lighting Gas Supply Company	80	30	Coles Levee to Newhall, California
Los Angeles, California	2.1	16–20	Potrero to Newhall, California
	2.8	16	Lines in East Whittier, California
Permian Basin Pipeline Company Omaha, Nebraska	83	16	Interconnection from proposed Pioneer's gathering system to Permian's facilities at Spraberry, Texas
Pioneer Gathering System, Inc.	70	—	Gathering system in Val Verde, Sutton, and Schleicher counties, Texas
Tennessee Gas Transmission Company	264	26, 30	Loops in Tennessee, Kentucky, West Virginia and Pennsylvania
Houston, Texas	557	30	From existing facilities in Mississippi Delta south of New Orleans to Portland, Tennessee
	76	24	Coudersport, Pennsylvania, to Hamburg, New York
Texas-Illinois Natural Gas Pipeline Company Chicago, Illinois	59	20	Joliet to Volo, Illinois
Transcontinental Gas Pipe Line Corporation	13	24	Purchase lateral in Louisiana
Houston, Texas	213	12–24	Purchase laterals in Texas
Westcoast Transmission Company, Ltd.	174	30	Line from Savannah Creek gas field, Alberta, to existing system

Digging range: Depth to 5'6". Width 19½" to 30".

a new advance for heavy-duty digging . . .

Barber-Greene Wheel Ditcher

This new development is Barber-Greene's latest addition to the four outstanding ditchers in the field.

Pace-setting features include:

New digging-wheel differential and split #1 shaft assure constant gear tooth contact on both sides of wheel . . . equalize torque . . . eliminate uneven stresses.

New flexible connection between chassis and boom eliminates excessive strain, twist and tilt on curves.

New Hydra-Crowd assures optimum digging speeds through independent, finger-tip control of crowding speeds—infinitely variable without shifting gears.

New electric overload release — provides overload protection without adjustment.

New all-hydraulic spoil conveyor— instantly reversible — operates independently of wheel. Infinitely variable speed to 650 f.p.m. permits accurate placement of spoil alongside ditcher.

New hydraulic controls — including hydraulic brakes — make operation easier, more accurate.

Advance models of this new Barber-Greene ditcher have already established a reputation for superior performance under the most grueling conditions.

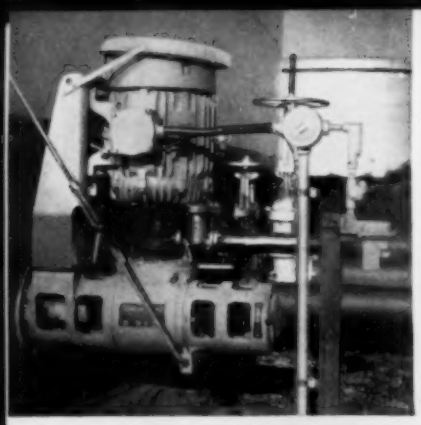
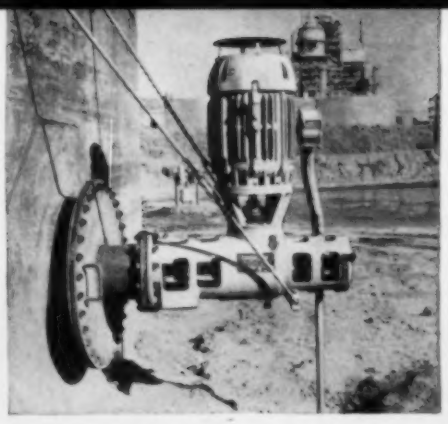
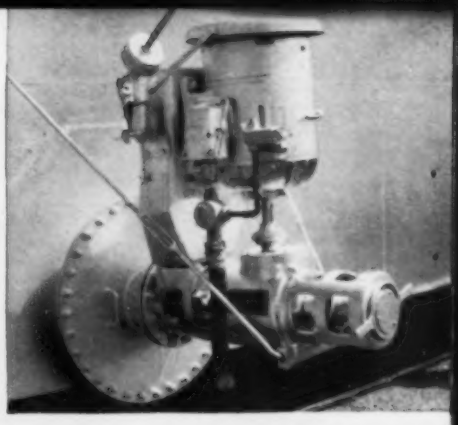
Write for information on this newest ditcher in the Barber-Greene line of advanced design.

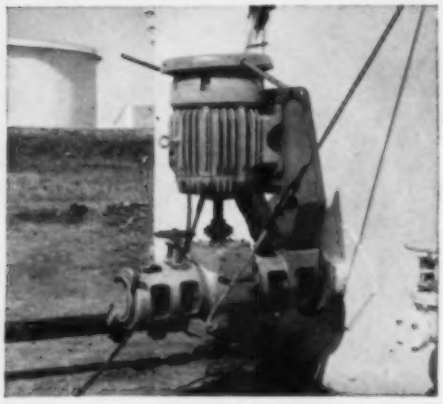
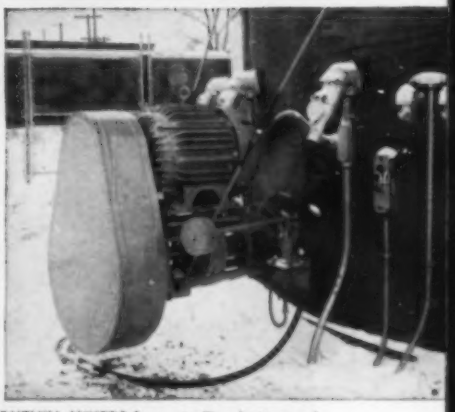
57-1-D

Barber-Greene BG

AURORA, ILLINOIS, U.S.A.

CONVEYORS . . . LOADERS . . . DITCHERS . . . ASPHALT PAVING EQUIPMENT

YOU CAN GET LIGHTNIN MIXERS for controlling bottom sediment in any tank, regardless of capacity.

How 50 pipe line companies keep tank bottoms clean . . . by pressing a switch

More than 50 independent pipe line companies, and some 35 leading producers and refiners, have found an easy way to say good-bye to sludge cleanout costs in crude storage tanks.

Uniform crude; no sludge pile-up; dramatic savings—these are the results when you control sediment by flipping the switch on a LIGHTNIN Mixer.

Saved: $1,000 per tank per year

If your tank cleaning costs are about average, you lose from $5,000 to $8,000 every time you clean out an 80,000-barrel tank. These cost figures include a conservatively estimated $2,000 in marketable oil and wax lost in the bottoms. Often, this loss runs much higher—as high as $6,000 in some cases.*

When you install LIGHTNIN Mixers, you eliminate sludge buildup for good. You can keep sediment suspended in the crude, or resuspend it if it has settled. You can blend crude stocks to prevent stratification, and to dispatch a uniform crude.

Savings, overall, are on the order of $1,000 per tank per year.

As a bonus, you keep full holding capacity of your crude tanks ready for use when you need it. You gain as much as 12% more storage capacity —without adding a single tank.

Your LIGHTNIN Mixer representative can tell you how much *you'll* save with LIGHTNINs in your crude storage tanks. Look him up in Composite Catalog and call him in. Or write us direct.

*Based on field studies by a major pipe line company. Details on request.

Lightnin® Mixers

MIXCO fluid mixing specialists

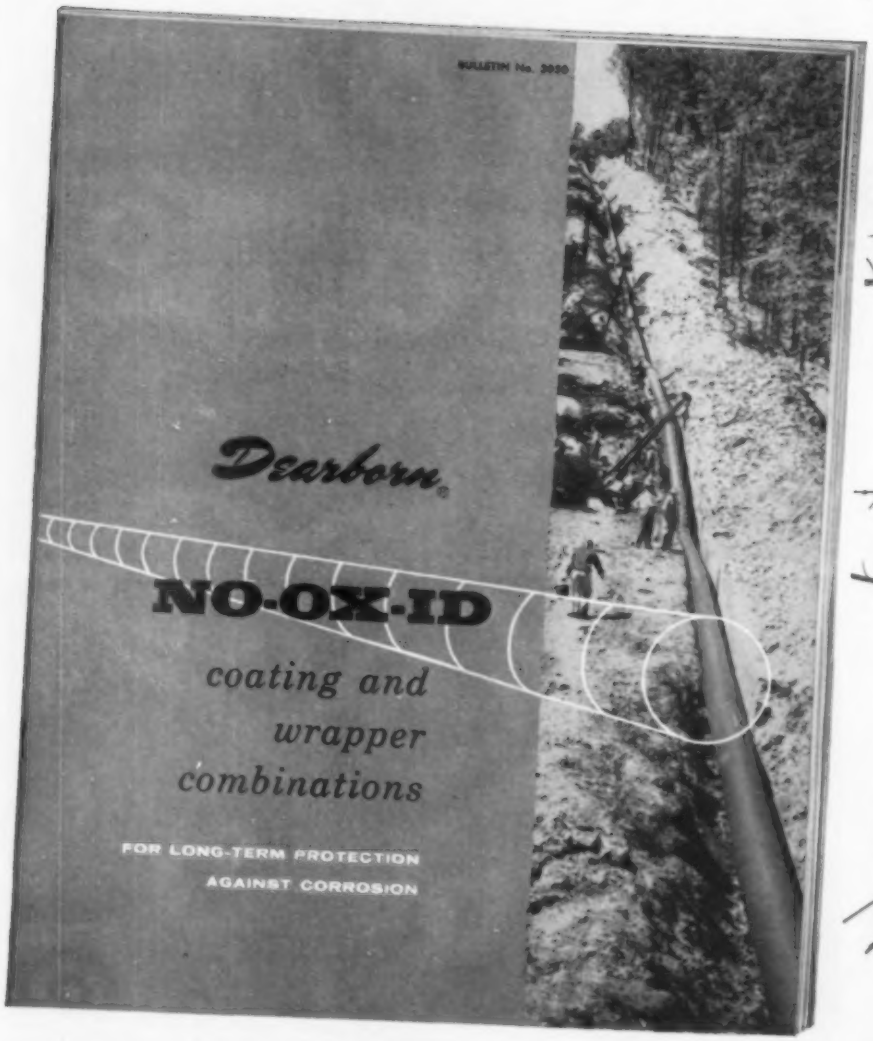
Get these helpful bulletins on BS & W control and LIGHTNIN Mixers. Check, tear out and mail to us today with your name and company address. Free—no obligation.

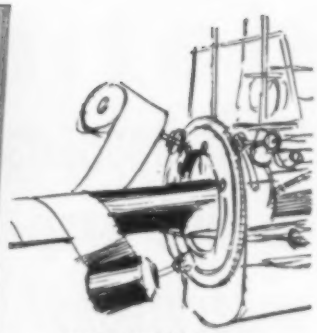
- ☐ B-503 BS & W Control with LIGHTNIN Mixers
- ☐ B-104 Side entering mixers, 1 to 25 HP
- ☐ B-107 Data sheet for figuring mixer requirements
- ☐ B-109 Condensed catalog describing LIGHTNIN Mixers —all types
- ☐ B-111 LIGHTNIN rotary mechanical seals for extra-low-cost mixing

YOU CAN MAINTAIN bottom sediment level of as little as one inch, year after year, with LIGHTNIN Mixers in your tanks.

MIXING EQUIPMENT Co., Inc., 127-h Mt. Read Blvd., Rochester 11, N. Y.

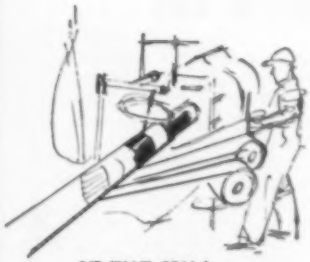
In Canada: Greey Mixing Equipment, Ltd., 100 Miranda Avenue, Toronto 10, Ont.





BY TRAVELINER

BY HAND



AT THE MILL

UP-TO-DATE INFORMATION ON PIPELINE PROTECTION ...NEW NO-OX-ID CATALOG

Dearborn has compiled a new 12-page illustrated catalog describing the latest approved methods of coating and wrapping underground or underwater pipe for long-term protection. Every pipeline contractor, utility and private operator will want a reference copy.

The catalog describes NO-OX-ID compounds and NO-OX-IDized Wrapper combinations developed for corrosion control under all soil conditions. It tells how to apply NO-OX-IDs, hot or cold, by Traveliner, by hand or at the mill...how to get more pipe coverage with less equipment and smaller coating crews.

It pays to specify

Dearborn NO-OX-ID®

Specify NO-OX-ID combinations for long-term protection

Your copy is ready

Just fill out the coupon and mail...we will send your catalog promptly. Please indicate the number required for staff use. If you prefer, we will have a Dearborn Pipeline Engineer deliver the catalog when he makes his consultation call.

Dearborn Chemical Company
Merchandise Mart Plaza, Dept. PE, Chicago 54, Ill.

☐ Send me ..... (*quantity*) new Dearborn NO-OX-ID catalogs.

☐ Have a Dearborn Pipeline Engineer call with my copy.

Name.....*Title*.....

Company.....

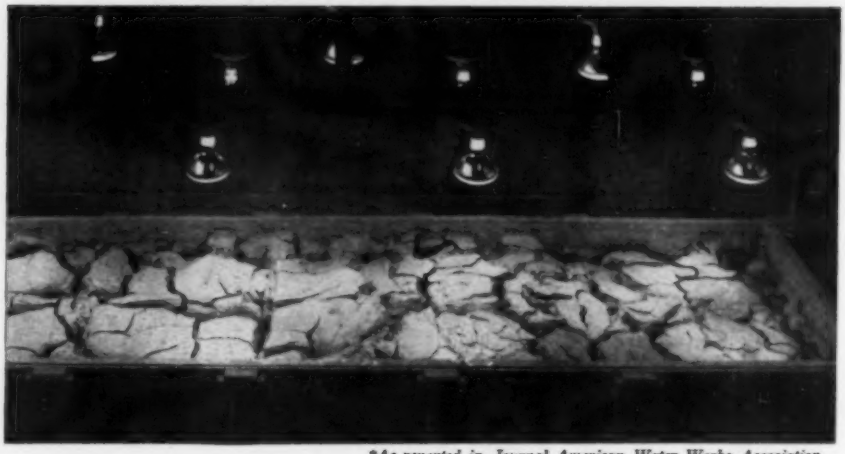
Address.....

City.....*Zone*....*State*.....

What happens to pipe wrap underground?

Here's what a federal agency found out*. . .

Many wrap and enamel combinations were imbedded in a test tank filled with bentonite clay slurry. Extreme soil stresses were imposed on these samples by alternate wetting and drying cycles. Resistance to backfill puncture was also checked after each cycle. Holiday-detection tests showed that the glass fiber and coal-tar combination stood up through the full 25 cycles of the test.



*As reported in Journal American Water Works Association, Vol. 48, Feb., 1956. Photo courtesy U.S. Bureau Of Reclamation.

These impartial tests show why BLUE FLAG gives you complete pipeline protection

It was conclusively demonstrated that glass fiber mat like Blue Flag, with coal-tar enamel, provides effective protection against *both* soil-stress and backfill-puncture action. (See picture caption above for actual test conditions.)

This is the kind of protection you need for maximum service life. Yet it's yours for only ½ of 1% of initial pipeline cost when you use L·O·F Glass Fibers' Blue Flag.

No wonder glass fiber reinforcement like Blue Flag Pipe Wrap is preferred. It strengthens enamel . . . assures coating essentially free of holidays. And, Blue Flag helps speed application—its high tensile strength virtually eliminates breakage in the wrapping operation.

Yard-wrapped, or applied over-the-ditch, Blue Flag can be the answer to your pipeline protection problems. It's available from conveniently located distributor warehouses. For the address of the one nearest you, or for technical information, write: *L·O·F Glass Fibers Company, Dept. 72-87, 1810 Madison Avenue, Toledo 1, Ohio.*

L·O·F GLASS FIBERS

L·O·F GLASS FIBERS COMPANY • TOLEDO 1, OHIO

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Important? Yes...but definitely no secret

EVERYONE IN PIPELINING KNOWS ABOUT GASO

Talk to anyone active in pipelining about GASO Pumps and he'll tell you they're such a familiar sight in the field that pipeliners think of them as standard equipment. It's a reputation based on performance that would be hard to believe were it not confirmed by accurate cost records. We're as close to you as our nearest distributor.

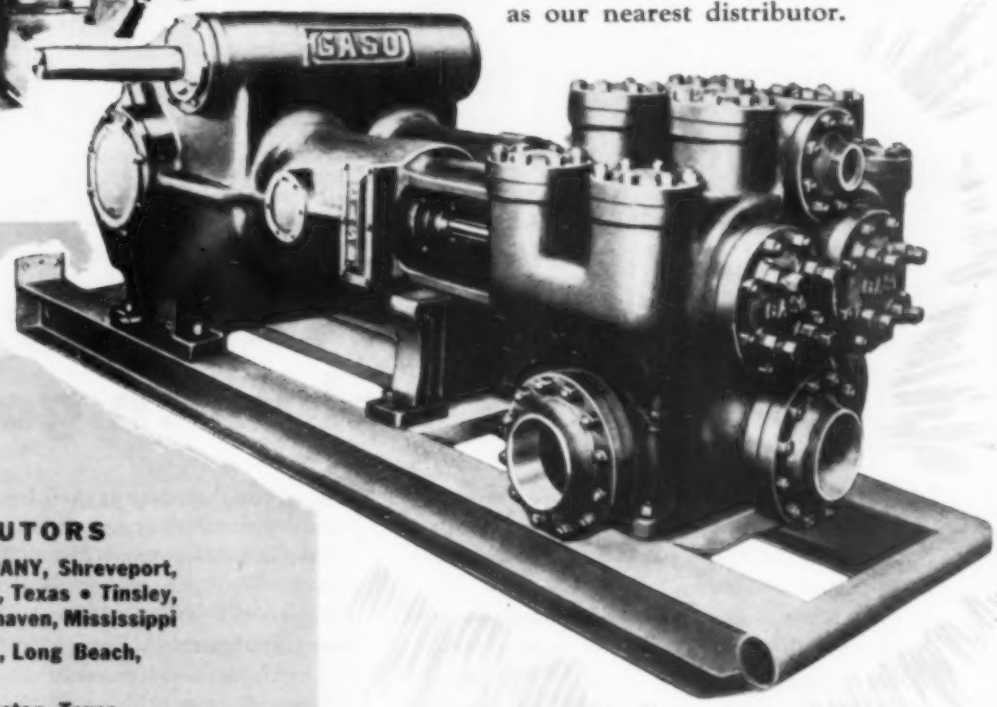


Fig. 2651-2652 — Gaso 12" stroke Duplex Piston Power Pump. Largest of Gaso models designed to pump oil or water through long lines at pressures from 475 to 1500 psi.

DISTRIBUTORS

W. L. SOMNER COMPANY, Shreveport, Louisiana • Odessa, Texas • Tinsley, Mississippi • Brookhaven, Mississippi

POWER PUMPS, INC., Long Beach, California

PEDDLERS, INC., Houston, Texas

PUMP ENGINEERING CO., Wichita Falls, Texas

LUFKIN FOUNDRY & MACHINE CO. Casper, Wyoming

HAGUE EQUIPMENT CO., INC. Evansville, Indiana

LUFKIN MACHINE CO., Ltd. Edmonton, Alberta

GASO PUMP & BURNER MFG. CO.

TULSA, OKLAHOMA

EXPORT OFFICE: 149 Broadway, New York

GASO PUMPS

for every oil industry need

COMPRESSION RING . . . 1-piece, quick-seating. Maximum strength. Turned finish on outside diameter lets ring conform readily to the cylinder bore. The chemically treated surfaces aid rapid seating, no scuffing or scoring during run-in. ½″ to 120″ diameters.

POROUS CHROME PLATED RING . . . exclusive Van der Horst process. Shallow porosity on cylinder contacting surface facilitates break-in, holds and distributes oil during this critical period. Lasts four times longer, cuts cylinder wear up to 75%. ½″ to 42″ diameters.

CONFORMABLE OIL RING . . . maintains constant pressure for positive oil control. Conforms to meet cylinder distortion; flexible cast iron member, pressed outward by abutment type spring exerts uniform radial pressure around entire circumference. 4″ to 25″ diameters, ¼″ min. width.

KOPPERS SEAL RING . . . has one or two projecting bands of bearing bronze inserted in contacting face. Very quick-seating. Tends to prevent blow-by in new or worn cylinders. The burnishing action of bronze on cylinder walls decreases scuffing and wear. 2″ to 30″ diameters.

GROOVED OIL CUTTER RING...valuable where oil control is a major problem. Two bevels for riding over oil on up-stroke, two scraping edges for removing excess oil from walls on downstroke, plus a series of wide drainage slots. 1½″ to 25″ diameters.

Five Koppers Rings . . . worth their weight in gold!

What will American Hammered Industrial Piston Rings *do for you?* They'll save you money on fuel, on lubricating oil, on labor costs—by reducing down-time.

They'll maintain high compression, improve your operation, give you *much* longer service. They don't cost much . . . but they have over 35 years of manufacturing skill and accumulated experience behind them. They never let you down, they never fail in the jobs they're designed to do—and hundreds of satisfied users will tell you that, despite their low cost, Koppers rings *are* worth their weight in gold.

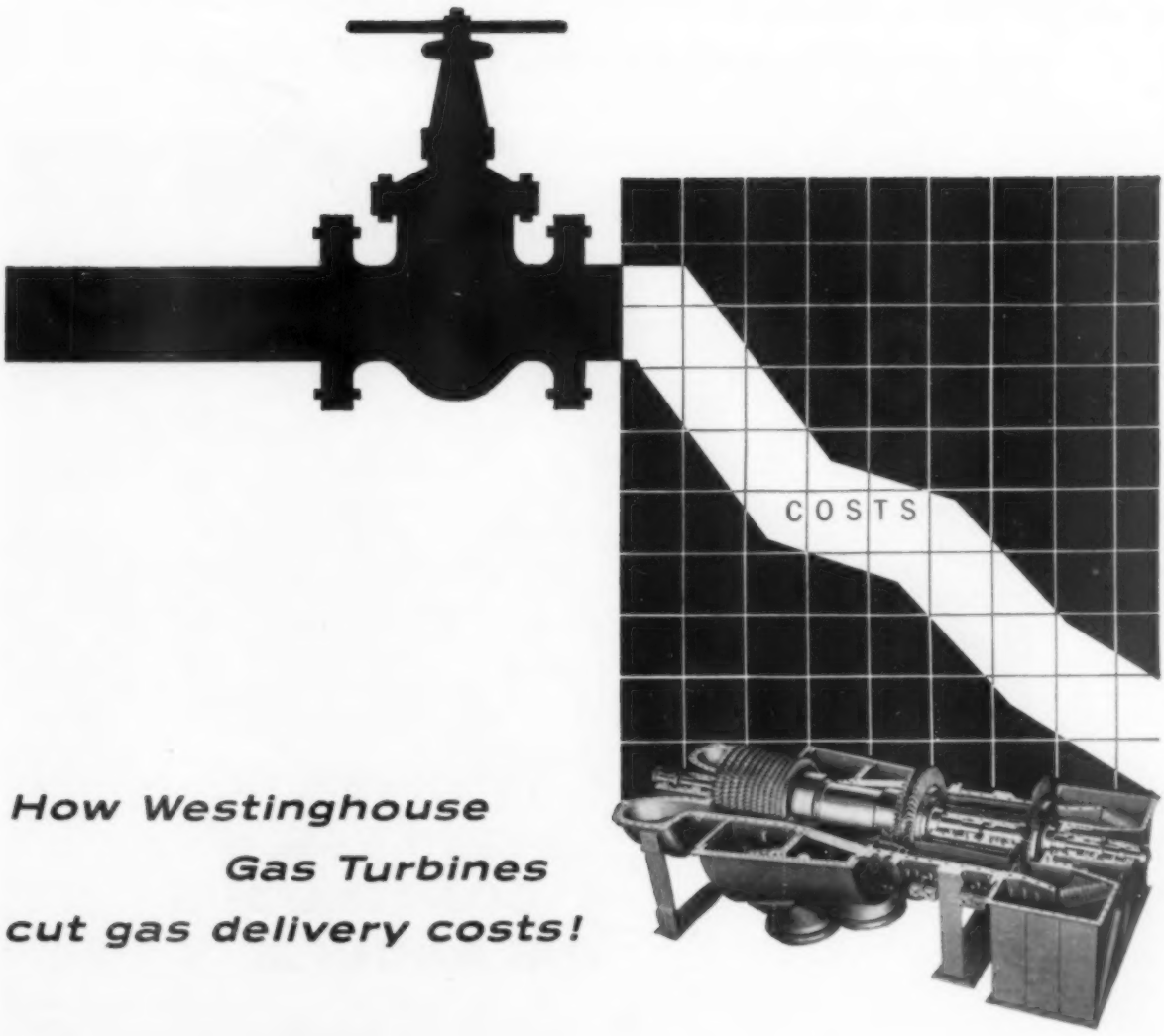
American Hammered Piston Rings are available in all types, all sizes—from ½″ to 10′ diameter—for every purpose. Koppers makes American Hammered Rings for all kinds of industrial equipment, can recommend without bias as to types. It costs nothing to consult Koppers—for illustrated Piston Ring booklet write to KOPPERS COMPANY, INC., *Piston Ring & Seal Dept.,* 1708 Hamburg Street, Baltimore 3, Md.

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • Baltimore 3, Maryland
This Koppers Division also supplies industry with Fast's Couplings, Industrial Gas Cleaning Apparatus, Aeromaster Fans, Gas Apparatus.
Engineered Products Sold with *Service*

KOPPERS

AMERICAN HAMMERED
Industrial Piston Rings

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



How Westinghouse Gas Turbines cut gas delivery costs!

EACH MONTH, MORE WESTINGHOUSE gas turbines are being installed for gas transmission. These orders indicate it's time to take another look at the savings offered by the modern Westinghouse gas turbine for pipeline pumping! Here's what you get:

Extra hp during cold weather—Up to 25% more horsepower . . . when you need it most!

Lower initial cost—based on unit horsepower, not considering the extra 25% during cold weather. And, usually, no reduction gear is needed.

Lower station structure cost—The gas turbine weight is less than 45 pounds per hp and the vibration level is low.

Simple maintenance—Lifting the cover exposes the entire gas turbine for inspection . . . a feature pioneered by Westinghouse.

Low operating costs—Minimum man power and low lube oil consumption are just two of the many operating cost advantages.

No cooling water needed — Eliminate water-handling problems and risk of water supply failure.

Challenge us to prove that the modern Westinghouse gas turbine can cut your gas transmission costs. Contact your Westinghouse representative or write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-50601

YOU CAN BE **SURE**...IF IT'S **Westinghouse**

Why **DYNALOG*** *design is out front of all electronic potentiometers . . .*

IT GIVES STEPLESS, CONTINUOUS BALANCING!

Advance features to improve control of temperature, pressure, flow . . .

1. No periodic maintenance
2. No dry cell—no standardizing
3. No high-speed moving parts
4. No slidewire or galvanometer
5. *Stepless*, continuous balancing
6. Adaptable to narrow spans

FOXBORO
REG. U.S. PAT. OFF.
DYNALOG
ELECTRONIC INSTRUMENTS

Here's precision in motion . . . the smooth, continuous balancing action of a Dynalog Electronic Instrument! No slidewire with faltering step-by-step inaccuracies . . . no sliding or rubbing contacts. Instead, a simple, variable, radio-type capacitor and positive magnetic drive. It's friction-free, wear-free.

That's why Dynalogs respond almost instantly to the slightest change in a process variable, with a sensitivity of 1/100 of 1% of scale . . . accuracy of ¼ of 1% of scale. It's also the reason they're the maintenance man's dream. About all he does is supply ink and charts!

Dynalogs are used with any primary element—resistance, voltage, capacity, inductive. They perform with effortless accuracy, even on control and recording problems that conventional balancing-type instruments can't handle. For the complete story, write for Bulletin 20-10. **The Foxboro Company, 388 Norfolk Street, Foxboro, Mass., U.S.A.**

*Reg. U. S. Pat. Off.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

TRENCHING MOVES FAST

When Bucyrus-Eries Move In

Trenching for a 24-in. natural gas pipeline in northern Pennsylvania near Honesdale is this Bucyrus-Erie 22-B dragshovel. The high pace this machine has set for its owner, Oklahoma Pipeline Constructors, Dallas, Tex., is characteristic of the features that have made Bucyrus-Erie dragshovels outstanding.

There's high speed on the hoist and swing as well as full digging power for heaped, quick-filling loads. The cambered boom provides added clearance for digging deep trenches, makes dumping easy because dipper can be raised high and brought in close without spilling the load. The dipper has sloping sides and extended lip area for clean loading and dumping.

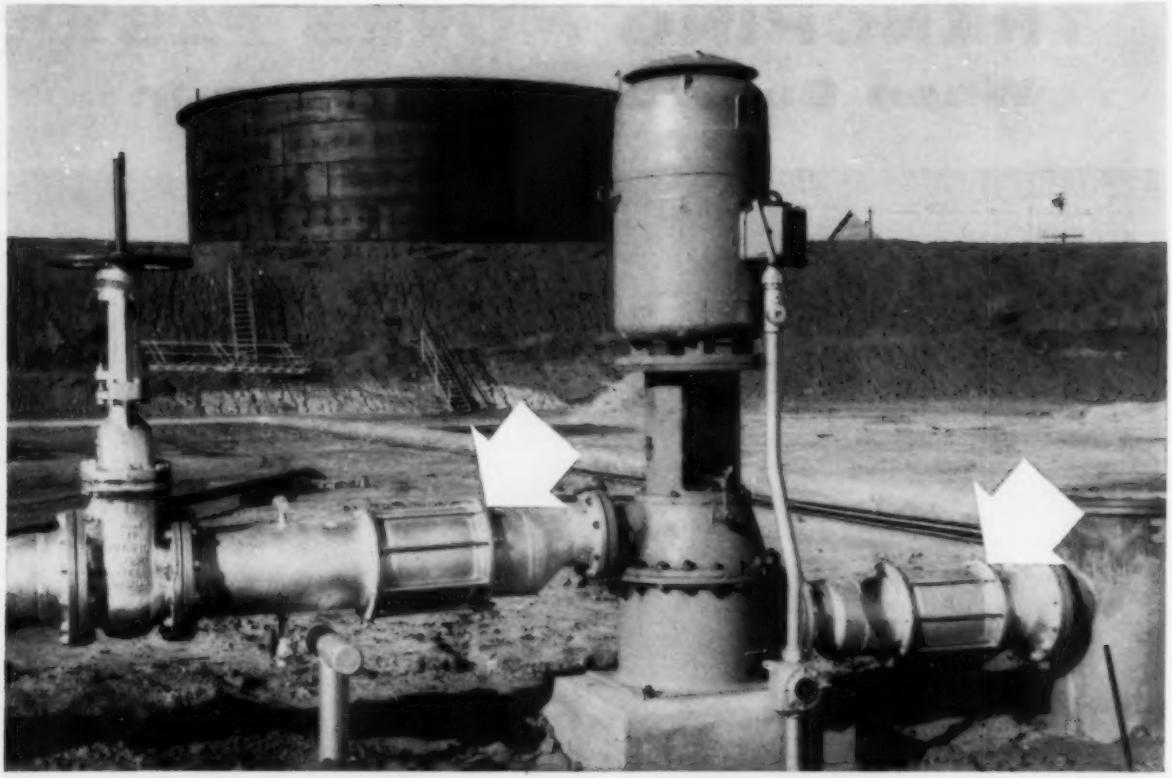
Tractor-type crawler mounting is available, too, for top mobility. It raises ground clearance enough to travel over rocks, stumps, and most other obstructions. Deep grousers on the tractor-type treads provide sure traction in soft ground and permit the machine to climb steep grades. Special seals protect track-roller bearings against damage from water, dirt, and grime.

For more information on the high-output features of Bucyrus-Erie ½-yd. 15-B, ¾-yd. 22-B (both available with tractor-type crawlers), and new 1-yd. 30-B dragshovels, see your Bucyrus-Erie distributor today. 384E57

BUCYRUS-ERIE COMPANY

South Milwaukee, Wisconsin

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



Dresser Style 40 Couplings on booster pump at work-tanks at products pipeline station.

Simplify Pump Installation and Maintenance ...the DRESSER way!

A wrench is the only tool needed to install or dismantle the Dresser Couplings shown above. They give you a permanent, vibration-absorbing, leakproof connection.

For fast, simple connections and repairs, time-tested Dresser Couplings and Long Sleeves are ideal for replacing damaged pipe sections, and for tie-ins. Complete size range.

To repair a porous weld, without shutting down the line, use a Dresser Porous Weld Clamp. Put it around the weld, draw up the bolts. It's that simple. Size 2″ through 31″.

For easy repairing of breaks, splits and holes in high pressure lines, use Dresser Split Repair Sleeves. No loose parts. No welding. Self-sealing end-gasket pressure increases as line pressure increases. Sizes 6″ through 24″ and larger.

For reinforcing welded joints, use Dresser Reinforcing Sleeves, made of best grade flange-quality steel plate. Vented against pressure build-up. Weld-over Sleeve for coupled joints also available. Both styles can be furnished in special sizes and shapes, in production quantities.

Furnished for pressures as high as 1000 lbs., or more, Dresser repair equipment simplifies dozens of maintenance problems. Buy them direct, or from our warehouses. Write for catalog.

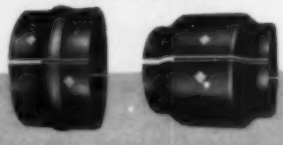
DRESSER®

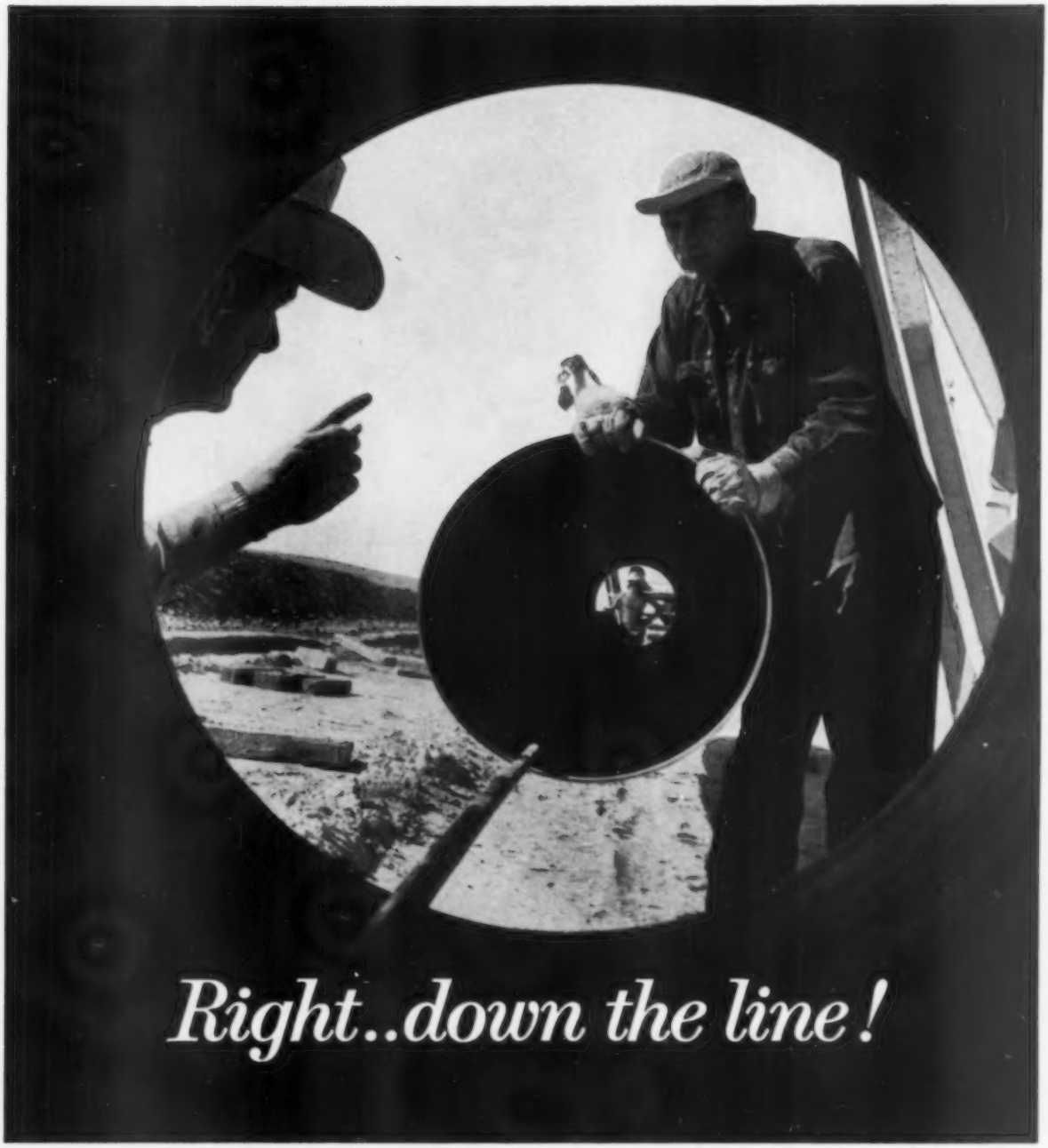
Dresser Manufacturing Division, 49 Fisher Ave., Bradford, Pa. Warehouses: 1121 Rothwell St., Houston; 101 S. Airport Blvd., S. San Francisco. In Canada: 1211 Bathurst St., Toronto; 1210 11th Ave., W., Calgary.

TO REPAIR POROUS WELDS

FOR BREAKS, SPLITS, HOLES

REINFORCING SLEEVES





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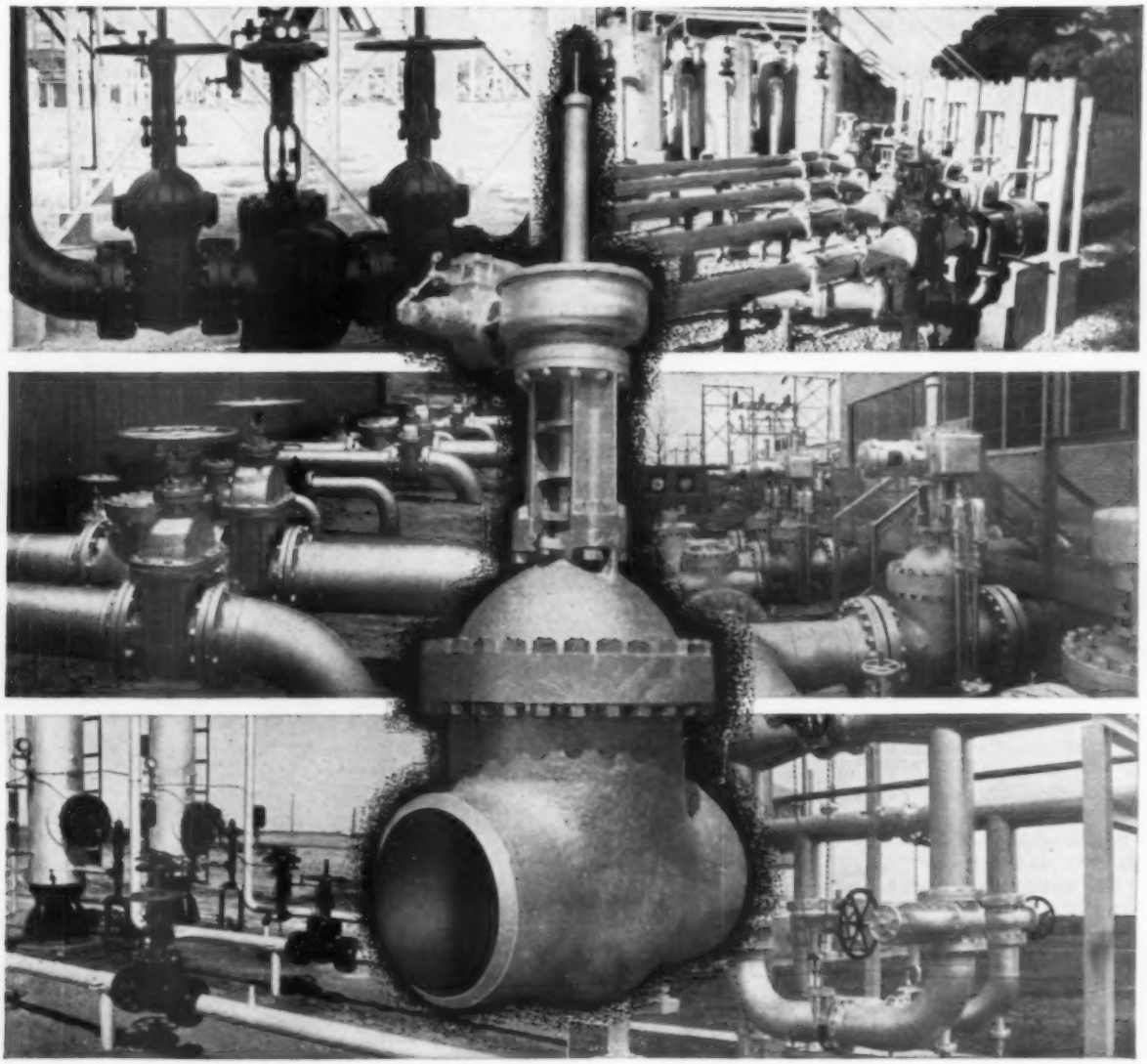

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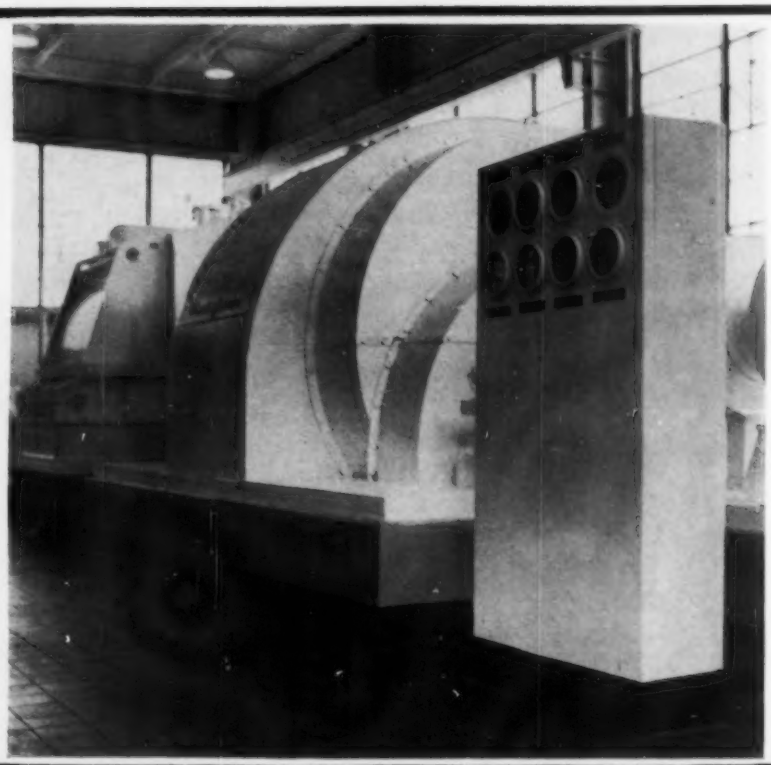


ONE day recently Texas Eastern Transmission Corporation loaded representatives of the petroleum press and key members of its own organization into a private DC 3 and took them on an air tour of four of its stations. In a matter of four days approximately 2500 miles were covered. Stations inspected were representative of the several types Texas Eastern has installed on a system that had its origin in conversion of the War Emergency Pipelines from oil and products service to natural gas transmission.

Revealed for the first time were details of a completely different type of compressor station at Mt. Pleasant, Tennessee, which has its counterpart at Egypt, Mississippi, and Tompkinsville, Kentucky. This is a single-unit station consisting of a 15,000-hp synchronous electric motor driving a single-stage centrifugal compressor through a 900 to 6506-rpm speed increaser.

The 15,000-hp motor, specially built, is the largest in use in gas transmission service. Other features of the station included:

- Across-the-line starting.
- A single-stage compressor that develops a compression ratio of 1.5:1, highest yet achieved.
- Electronic surge control.
- Low investment cost. Total cost of the station was $1,710,530; cost per installed horsepower, $114.04. This compares, for example, to a total cost of $2,527,497 and per horsepower cost of $168.50 for the six-unit station at Gladeville, Tennessee.
- Low operating cost.

About the 15,000-hp Motor

Rating. 15,000 hp, 3-phase, 60 cycles, 100 percent power factor, 900 rpm, 4160 v, 1580 amp full load. A 30-kw, 125-v exciter is direct-connected to the motor.

Force ventilation is by a 30,000-cu ft per min blower, with a duplicate spare, each driven by a 30-hp explosion-proof motor. Blowers and motors are situated outside the station building. Ventilating air removes loss heat from the motor, exciter, and motor collector, and maintains a pressurized condition with safe air in these housings. Exhaust air is discharged outside the building with provision for air recirculation and use for heating the building in cold weather.

Efficiency is in excess of 98 percent. Operating at 100 percent power factor, the motor draws minimum current from the line for the power delivered.

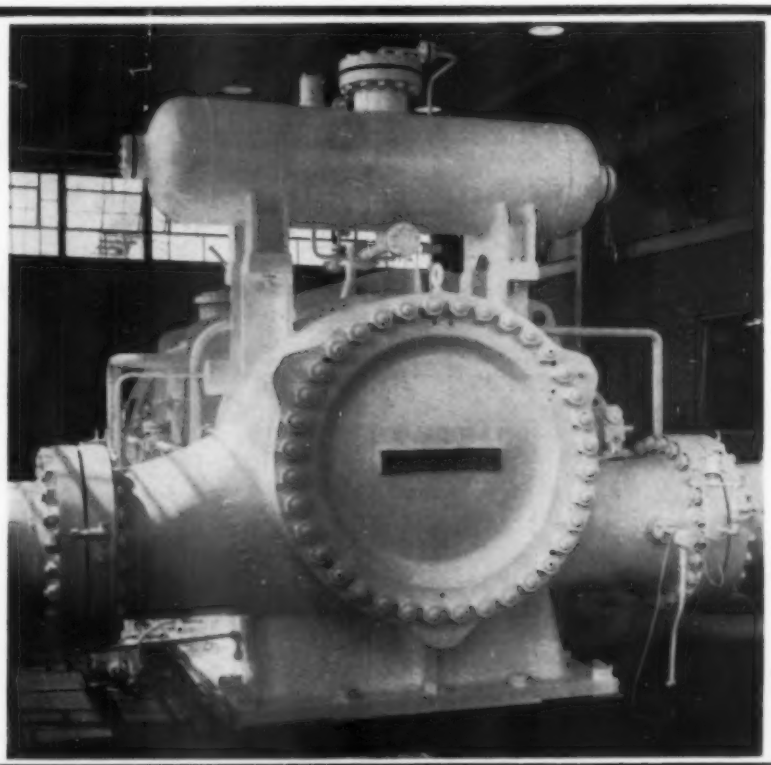
Starting performance. The motor delivers full-load torque of 87,500 ft-lb, and this is the approximate torque both at starting and at 95 percent speed, with full voltage of the stator windings. The motor is started across-the-line by closing the breaker connecting it to the 4160-v station buss in the outdoor switchgear at the substation. Starting current at full voltage is 8000 amp, but the motor voltage and resultant current drawn are somewhat reduced by reactance drop in the 16,000-kva transformer supplying the station.

The motor-gear-compressor system is a relatively high inertia load, having $W\bar{R}^2$ of about 170,000 lb-ft^2 referred to the motor shaft. This means about 43,000 hp-sec of energy is delivered to accelerate the drive.

An equivalent heating effect occurs in the motor rotor, requiring special

They are the only ones of their kind in gas transmission service and required specially built equipment

Unit Stations



This 15,000-hp synchronous motor at Mt. Pleasant, Tennessee, station drives a single-stage centrifugal compressor through a 900 to 6506-rpm speed increaser.

The single-stage compressor has a compression ratio of 1.5:1, highest yet achieved. Note The emergency seal oil tank rests directly on the compressor.

construction of the starting winding. This winding consists of metallic bars embedded in the pole faces of the rotor and brazed to segmental end rings to form a cage winding similar to that of an induction motor. The end winding segments, instead of being bolted together between poles as is usual, are joined by flexible connectors made of thin copper strips silver plated to maintain surface conductivity. The drive accelerates in about eight seconds, after which the control equipment applies excitation automatically at the correct speed and most favorable rotor position for smooth synchronization.

When the motor is running synchronized its starting winding is inoperative, hence it is designed for maximum starting effectiveness without impairing the running efficiency of the motor.

Windings. Motor windings contain about 12,000 lb of copper, installed in slots in the laminated active iron of the stator, and wound on eight laminated steel poles dovetailed to the rotor. These windings have a total length of 10 miles.

Speed increasing gear unit. The 17,250-hp rating of the speed increasing gear unit is based on the driving motor rating of 15,000 hp with a 1.15 service factor. The ratio 1:7.229 provides an output speed of 6506 rpm with the 900-rpm input motor speed.

The high stored energy in the rotating parts of the system makes a difficult starting condition, so the gear was designed for minimum inertia. The problem became one of keeping the low speed gear diameter to a minimum, since the inertia torque of this gear represents by far the major portion of the total mass of the gear unit.

To reduce the low speed diameter meant attempting to reduce center distance. In order to maintain sufficient horsepower capacity, this in turn meant widening the face. Widening the face, of course, increases the bearing span, and in the high speed shaft this presents a problem of deflection. These considerations led to a final design calling for a gear unit having a 42-in. center distance and 34-in. face, with the gearing being heat treated. The heat treatment, of course, allowed a higher rating on the unit than would have been allowed on a similar unit with non-heat treated gearing.

An unusual step of major proportions was taken in design by using three bearings for the high speed shaft. This reduced the high speed bearing spans and thereby eliminated the problem of the high speed shaft deflection. The unit is built as a WR^2 of approxi-

mately 68,000 lb-ft² including the low speed coupling.

The low speed gear is fabricated with a forged-steel alloy and a forged-steel hub, whereas the high speed pinion is of forged steel, the pinion being integral with the shaft.

The low speed coupling is so constructed as to limit the end float of the motor shaft to 3/16-in. The high speed and low speed shaft extensions are tapered to facilitate servicing in the field.

The main lube oil pump, coupled directly to the gear unit low speed shaft, supplies oil for lubrication and cooling for the complete installation, including the motor bearings, gear unit, and compressor.

The main oil sump is situated in the bedplate directly beneath the gear. Oil from the gear drops directly into the main sump from where it is drawn back into the suction line of the pump. The seal oil pump is connected directly to the high speed shaft. For starting, stopping, and emergencies, an auxiliary motor-driven lube pump and an auxiliary motor-driven seal oil pump are utilized. These pumps are started and stopped automatically by means of pressure switches.

To eliminate any need for water at the site of installation, air-to-oil fan-type coolers were provided. There are three coolers at each station of this type situated outdoors and enclosed by a fence. As the ambient temperatures vary considerably, the coolers were selected to provide a wide range of adjustment, the adjustments being automatically controlled. These adjustments are effected by the fans being driven by a two-speed motor, louvres on the fan housings being adjustable, and the piping and valving being such that the oil can by-pass the coolers.

Cooling design was based on: (1) Highest ambient temperature on the hottest day, 104 F, and (2) 86.5 gal per min of oil to be cooled by each cooler from 160.8 F to 130 F, each cooler dissipating 9200 Btu's per minute and each having capacity to handle half the total heat load of the compressor-gear-motor installation. Three coolers were installed at each station to allow servicing of one unit while two are operating.

In the oil sump, six 5000-watt immersion heaters were installed to help maintain proper oil temperatures in cold weather and to prevent condensation in the sump.

Efficiency of the gear unit at full load is approximately 98 percent. It has a total operating weight of about 45,000 lb, the low speed gear and shaft weighing approximately 13,000 lb.

Control Desk

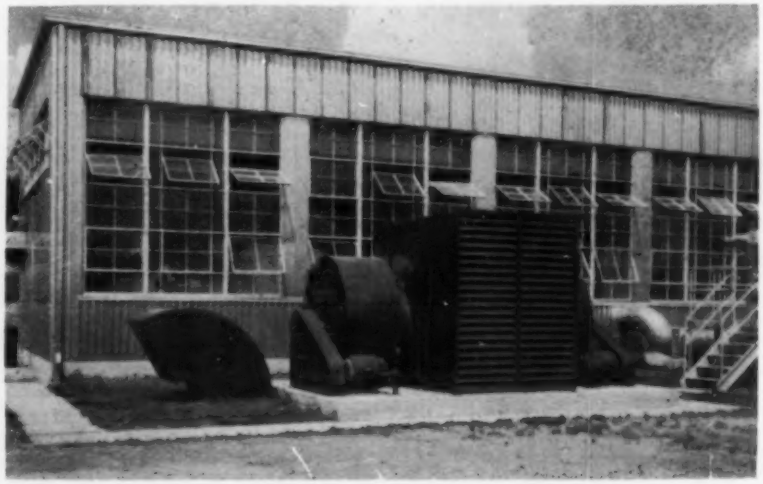
A control desk, installed in the control room beneath a window viewing the compressor room, is the operating center of the station. The sloped top of the console (36 in. by 24 in.) contains a simplified diagram of the main unit and associated piping, with indicating lights for the unit suction, discharge and recycle valve, motor and exciter; pushbuttons for starting and stopping the unit, controlling the recycle valve, and emergency station shut down. Indicating instruments show buss voltage, motor input, kilowatts, amperes, and kilovars.

Instrumentation Panels

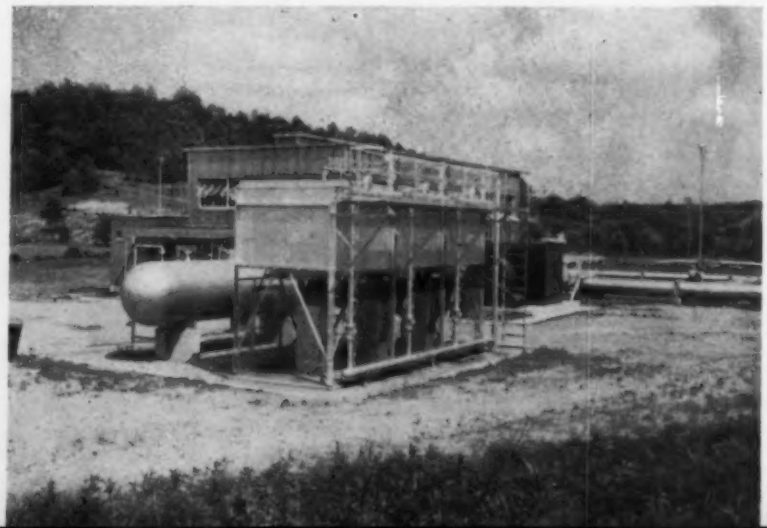
Station instrumentation and sequence relays are housed in two cabinets in the control room. These units mount:

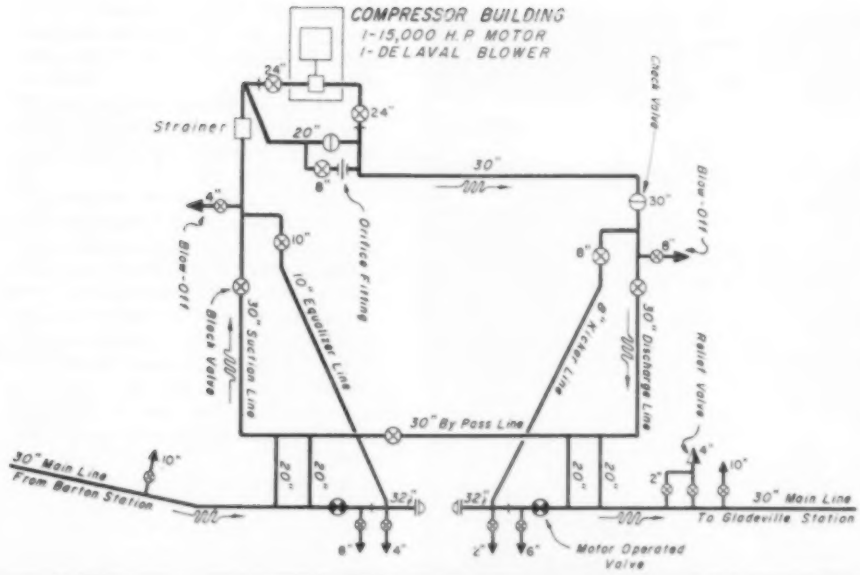
1. Station suction and discharge pressure indicating receivers.
2. Station suction and discharge pressure common recording receiver.
3. Temperature recorder, 24 point with temperature detectors in motor windings, motor gear and compressor bearings, compressor case, and oil cooler inlet and discharge.
4. Temperature recorder for suction gas, discharge gas, and outside air temperatures.
5. Load controller, which positions unit suction valve for throttling control responsive to motor load. (Automatically.)
6. Indicating light to show energizing of incoming line.
7. Ground detector lights on auxiliary system.
8. Annunciator.
9. Lockout relays.
10. Selector switch for local, or possible future, remote starting.

A 30,000 cu ft per min blower, with duplicate spare, removes loss heat from the motor, exciter, and motor collector, and maintains a pressurized condition with safe air in these housings.



Three bays of parallel connected forced air cooled fin tubed radiators provide cooling for oil.





Diagrammatic sketch of major piping at Mt. Pleasant station.

The system is designed to permit future operation of the station remotely by supervisory control.

Starting and Stopping the Station

Starting and stopping the station is entirely automatic, initiated by a single pushbutton. The sequence is as follows: With station suction and discharge valves open, station auxiliaries are initiated by pushbutton. These auxiliaries are the lube oil pump, gas compressor seal oil pump, and forced air ventilating system. After a preset period of time the gas compressor is purged. This is accomplished by the case pressurizing valve opening and allowing gas to enter the compressor case and associated piping, then exhausting to atmosphere through the case venting valve. After a preset time has elapsed the case pressurizing valve closes and the compressor case depressurizes to atmospheric pressure. Next, the main drive motor starts and when it is running normally the compressor case pressurizing valve is reopened and the case venting valve closed. When pressure within the compressor case reaches a preselected pressure the unit suction valve begins to open, as does the unit discharge valve. After the suction valve has reached an open position that is sufficient to avoid surge it stops and waits for the discharge valve to come wide open. When the latter is open, further opening of the suction valve is controlled by the automatic station load controller.

Centrifugal Compressor

The centrifugal compressor is a single-stage single-suction unit, and, being driven by a constant speed motor, is equipped with adjustable inlet guide vanes to impart flexibility of operation. Vanes can be adjusted for counter-rotation to provide maximum head and pressure ratio, or for pre-rotation, which reduces the head, pressure ratio, and horsepower. Adjustable vanes are an original Texas Eastern idea and were first used on the system's 2500-hp units.

Another feature is the fact that the diffuser and associated parts are changeable, making possible modification as expanded capacity is required. These are the compressor's operating characteristics:

Rotation (from driver end): Clockwise.
Suction pressure: 632 psia.
Suction temperature: 65 F.
Discharge pressure: 955 psia.
Station compression ratio: 1.51:1. (This is the highest compression ratio to be attained by a single-stage centrifugal compressor).
Rated volume: 10,050 cu ft per min.
Rated head, ft-lb per lb: 18,500.
Rated rpm: 6500.
Rated horsepower: 15,000.

Gas is sealed from atmosphere by a carbon seal against a ground steel collar. Interfaces are lubricated at a pressure regulated to 20 psi greater than case pressure. Seal oil and lube oil systems are supplied from a common reservoir having a maximum capacity of 1865 gal. In addition there is a 135-gal emergency seal oil tank, which is placed immediately on top of the compressor. This oil is available in event of complete failure of the seal oil pump, and is often used for starting purposes. Location of the emergency seal oil tank on the compressor unit is another Texas Eastern innovation, and is also practiced at its multiple-unit stations.

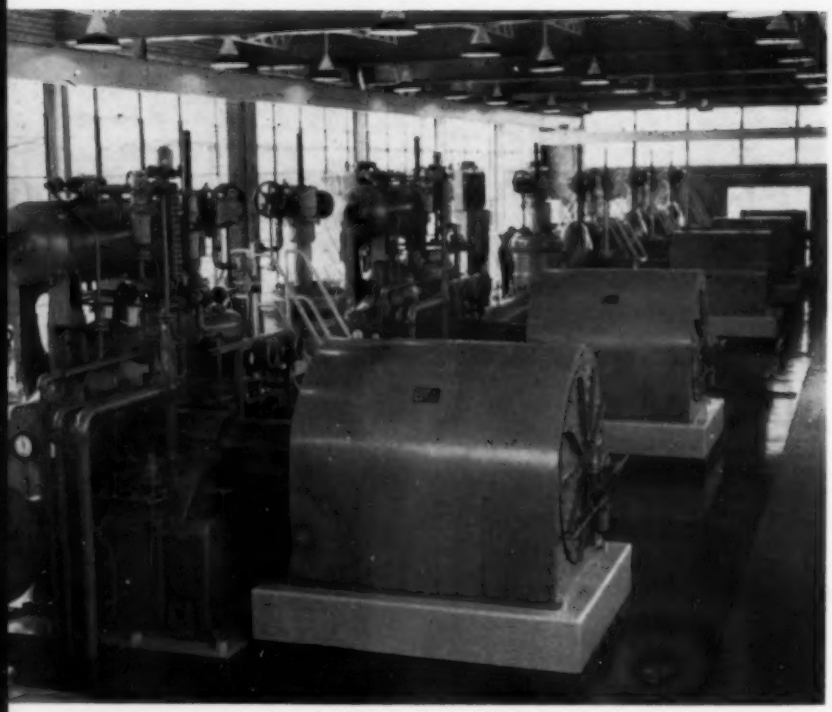
Emergency Shut Down

Four pushbutton stations and two manually operated valve stations actuate the emergency shut-down system, which close the station suction and discharge plug valves and open the two station blow-off valves while tripping simultaneously the motor circuit breaker to cut off the compressor drive motor. The system is designed to fail safely.

The emergency system also is designed for automatic activation in case of complete line failure or other type blowout either in the main line, station suction, or discharge line. These controls are situated at the station suction valve.

Surge Control

A surge control system developed by Texas Eastern is being tested at the Mt. Pleasant station. By means of an electronic device pressure change can be detected on the discharge side of the station. If the pressure begins to oscillate or "surge" the system gradually



Gladeville is a multiple-unit station having six 2500-hp motors driving single-stage centrifugal compressors.

opens a recirculating valve to give the compressor more load, eliminating the surge condition.

Actually, the device provides an extra dividend, so to speak, in that the operator can detect pre-surge conditions by means of the amplifier and can take steps to counteract the condition even before it is far enough along for the electronic equipment to take action. It is pointed out that one surge cycle occurs before the electronic device can control it, but this is not a critical condition and has no effect on the compressor unit.

Outdoor Electrical Substation

Special attention had to be given to design of the transformer, and especially to the inrush characteristics of the motor, in order to acccomplish across-the-line starting of the 15,000-hp motor. The station is in TVA territory, and proximity of a 161-kv power line contributed importantly to the successful application of this method of starting. The station site, in fact, was selected specifically for its relationship to the transmission supply line. Application of across-the-line starting has not resulted in any undue disturbances on the incoming power line, and is estimated to have saved $75,000 initial cost.

Incoming line breaker. The oil circuit breaker, which provides station isolation and protection to the 161,000-v incoming power line, is rated 1200 amp, 161 kv, with interrupting capacity of 5,000,000 kva. It is electro-pneumatically operated. Physically it consists of three individual pole units connected mechanically to operate simultaneously as a three-pole breaker, mechanically and electrically trip-free.

Disconnecting switches for breaker isolation are 1200-amp, 161-kv, three-pole, single-throw type, vertically mounted and gang-operated.

Transformer. The transformer is a 12,000/16,000-kva, three-phase unit, oil insulated, with forced air cooling fans for 16,000 kva. It is controlled automatically from the winding-temperature relay. Full load efficiency exceeds 99 percent. Sealed tank construction, utilizing inert gas above the oil, prevents deterioration of oil and insulation by oxidation.

Overall height of the transformer is approximately 24 ft including insulating bushings, and the unit weighs approximately 132,000 lb.

Outdoor metal clad switchgear. Outdoor switchgear consists of five cubicles. Unit No. 1 provides relaying for the incoming line breaker, and throat-connects the 4160-v 2000-amp station buss to the main transformer. This unit also contains a 48-v nickel-cadmium control and tripping battery with charger, as well as capacitor and arrester for surge protection of the main motor.

Unit No. 2 houses instrument and control transformers, 5-kv voltmeters, recording voltmeter, and integrating watthour meter.

Unit No. 3 contains two 2000-amp drawout breakers for controlling the main motor and 1 spare. It also has a 2000-amp indicating ammeter and protective relays for the main motor.

Unit No. 4 contains a similar breaker feeding a 225-kva auxiliary transformer, with protective relays and ammeter.

Unit No. 5 contains a duplicate spare breaker and breaker test facilities.

Auxiliary power center. The 225-kva auxiliary power center consists of a 4160/480-v, three-phase, oil-insulated, air-cooled unit with primary conduit entrance chamber and secondary breaker cabinet.

Gladeville Compressor Station

The station at Gladeville, Tennessee, is one of four similar installations built at the time of original construction of the 775-mile 30-in. main trunk line from Kosciusko, Mississippi, to Pennsylvania. Originally the station had three 2500-hp electric motors driving single-stage centrifugal compressors. Later, after intermediate stations had been built on the 30-in. line to increase capacity, the station was expanded by addition of three more 2500-hp units. The six units are arranged for series-parallel operation, i.e., two parallel groups of three units in series.

The original Gladeville station, and the other three stations installed at the same time, included the first application in gas transmission service of adjustable guide vanes for centrifugal compressors. These vanes increase the flexibility of compressors driven by constant speed motors.

Air-to-oil coolers in the lube and seal oil systems also was introduced at this station. Seal oil systems of the old and new compressor units at this station give a ready picture of progress in this respect. Emergency seal oil tanks of the original units are supported well overhead of the compressors, whereas on the later units they are supported directly from and above the compressor case.

Another innovation: Fire walls, usually associated with this type station, were eliminated, and safety accomplished by using forced draft ventilated motors.

A further interesting arrangement noted at this station was that only half the incoming gas stream is scrubbed. Gas not scrubbed goes through an overhead by-pass into the station suction. As rocks and other large foreign matter cannot climb a hill, so to speak, they drop out here. Removal of smaller material is held unessential in the case of centrifugal compressors. The other half of the gas stream is scrubbed by a bank of three scrubbers in parallel, having a total capacity of 387,000,000 cu ft a day.

Prime movers. The six 2500-hp motors are squirrel cage induction units, two-pole, three-phase, 60-cycle, 3600-rpm, 4160 v, 290 amp, with base ventilated enclosure. There are two ventilating fans each of which provides 42,000 cu ft per min at 1½ in. water static head.

Compressors. The single-phase compressors have a single suction, overhung 35-in. diam impellers, 24-in. flanges, and adjustable inlet guide vanes, as mentioned. Table 1 gives the operating characteristics at this station.

TABLE 1. Compressor Operating Characteristics at Gladeville.
(Two parallel groups of three units in series — split suction.)

	1st Stage Each Group	2nd Stage Each Group	3rd Stage Each Group
Suction pressure, psia	649	739.5	841
Discharge pressure, psia	739.5	841	956
Suction temperature F	65	84.7	104.6
Discharge temperature F	84.7	104.6	125
Inlet cfm	4880	4457	4060
Capacity, M³scfd	330	330	330
Head developed, ft-lb/lb	5600	5800	5950
Shaft speed, rpm	3570	3570	3570
Rated hp	2500	2500	2500
Present impeller diameter, in	35	35	35
Rotation (from drivers end)	Clockwise	Clockwise	Clockwise
Case hydrostatic test pressure	1500 psi	1500 psi	1500 psi

Station compression ratio: 1.473:1

Athens Station

Still another type of station was installed at Athens, Ohio. Here two 7600-hp gas turbines drive two gas compressors in series. An important design feature is the "straight-through" gas piping between the compressors, the discharge of one unit being connected directly into the suction of the second, with no expansion-loop connections between compressors. It is a simple piping arrangement, pioneered by Texas Eastern, and one that they hold is less costly and more efficient.

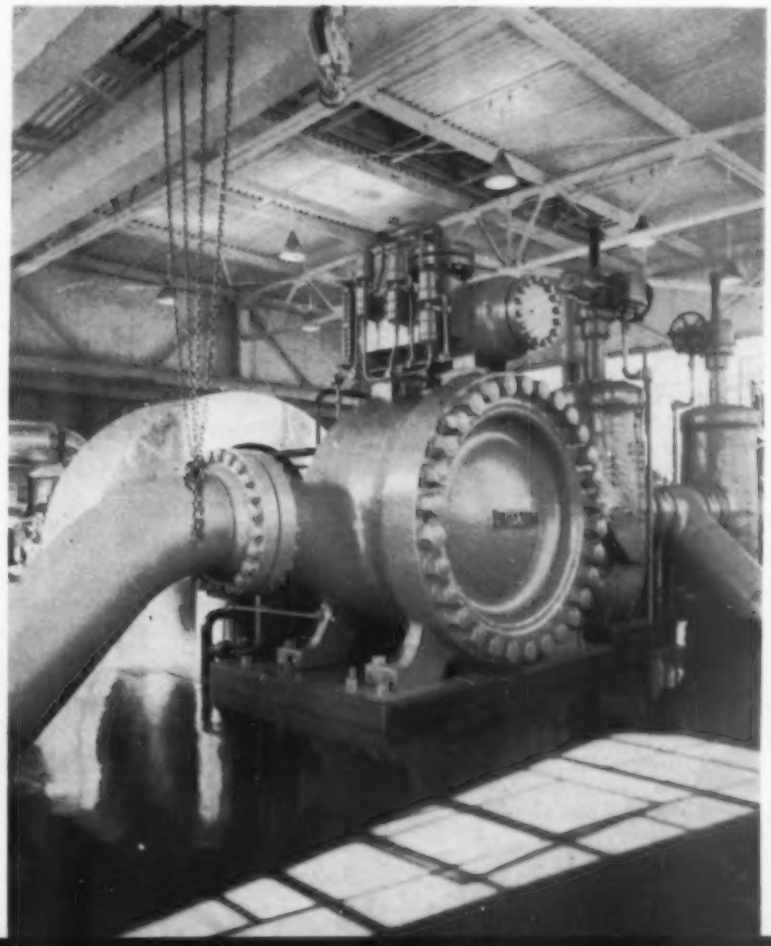
These gas turbines are unique in that they were the first ones manufactured in the 7600-hp size and are the largest in natural gas transmission service. To give maximum access and facilitate maintenance of these horizontally split casing machines, the exhaust is turned downward and the regenerators set to one side. This arrangement of duct work, and mounting the turbines on fabricated steel bases, made it possible to lower the operating floor considerably in relationship to previous installations. Simplification of the concrete foundations beneath the turbines also was a result. All these factors contributed to low cost installation. Cost of the Athens station was $3,026,400, or $199.11 per installed horsepower.

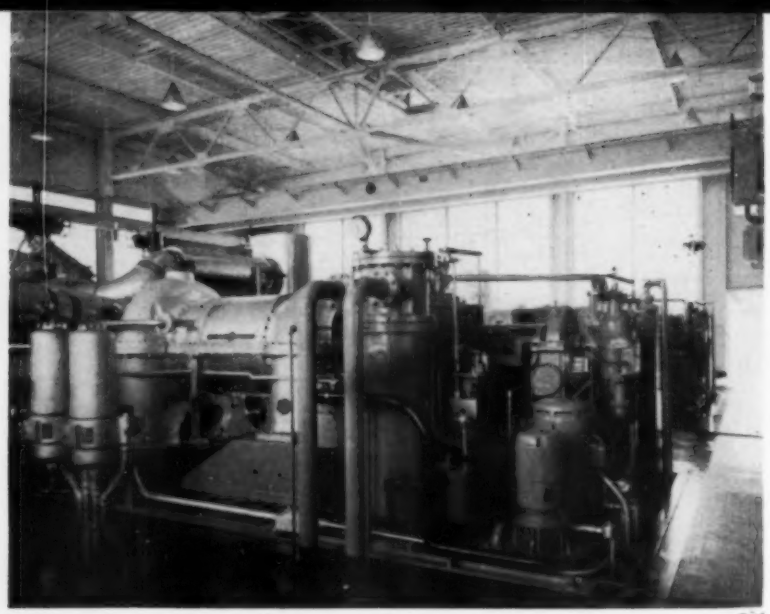
Prime movers. Gas turbines are of two-shaft, open-cycle type. Each is provided with a regenerator, pipe and duct connections to the regenerator, air intake silencer, gas-expansion starting turbine, lubricating system, speed governing equipment, sequential starting controls, safety shut down and alarm equipment. Design data are as follows:

- Fuel rate: 9.91 std cu ft per hp-hr
- Inlet air temperature at rating: 80 F
- Speed, power gas turbine, rpm: 5400
- Speed, axial air compressor, rpm: 6900
- Number axial air compressor stages: 14
- Number air compressor turbine stages: 1
- Number power gas turbine stages: 1
- Rotation (viewed from inlet end): counter clockwise
- Maximum combustor chamber temperature: 1500 F
- Power turbine inlet nozzle (adjustable): 24 vanes
- Net horsepower rating altitude: 1000 ft.

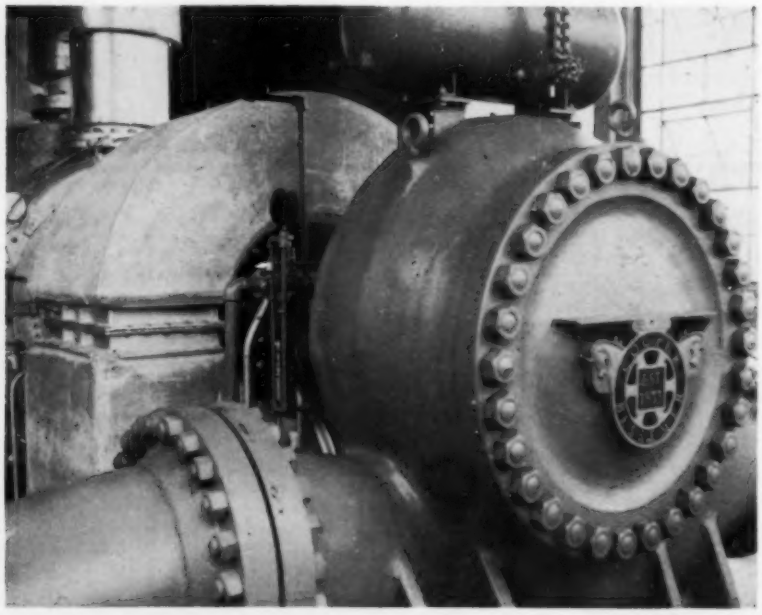
Gas compressors. The centrifugal compressors are single-stage, single-suction units with 32.6-in. diam impellers. Each unit has 24-in. flanges, vertical cover plate for repair accessibility, and fixed angle inlet guide vanes.

Athens station has two centrifugal compressors in series. "Straight-through" piping between the compressors is an important design feature.





Compressors at Athens are driven by 7600-hp gas turbines, the first to be manufactured in this size.



Grantville station is a single unit station consisting of a 5000-hp gas turbine to drive the direct-coupled single-stage centrifugal compressor.

Compressor operating characteristics are as follows:

- Rotation (from driver end): counter clockwise
- Suction pressure: 637 psia
- Suction temperature: 65 F
- Discharge pressure: 955 psia
- Station compression ratio: 1.50:1
- Discharge temperature: 126 F
- Rated volume: 10,120 cfm, or 672,000,000 scfd
- Rated head, ft-lb/lb: 17,960
- Rated rpm: 5400
- Rated horsepower: 7600

Strain tests. Extensive strain tests have been made at Athens with strain gages and other types of equipment to determine the stress pattern in piping and equipment during various operating conditions. Tests were also made while flanges were being tightened at time of construction. The tests are continuing, but the present conclusion is that stresswise the straight-through piping used at this station has provided a high degree of safety.

Grantville Station

Grantville station in Pennsylvania is on the Texas Eastern-Penn-Jersey Transportation Corporation's 24-in. main line, which extends from the Oakford storage field near Pittsburgh to Lambertsville, New Jersey. At Grantville a 5000-hp gas turbine does not require water services, as an oil-to-air lube oil cooling system has been incorporated in the station design.

Prime mover. The 5000-hp gas turbine is a two-shaft, open-cycle, mechanical drive unit with regenerator and variable speed control.

Design data follows:

- Fuel rate (based on natural gas HHV Btu/cu ft): 11.3 std cu ft per hp-hr
- Net horsepower rating at 1000 ft altitude
- Inlet air conditions of 80 F and 14.17 psig
- Speed, power gas turbine, rpm: 6000
- Speed, axial air compressor, rpm: 6200
- Number axial air compressor stages: 11
- Number air compressor turbine stages: 2
- Number power gas turbine stages: 1

Gas Compressor. The single-stage single-suction centrifugal compressor has an overhung 33.6-in. diam impeller. This unit also has 24-in. flanges, vertical cover plate, and fixed angle inlet guide vanes. Compressor operating characteristics are:

- Rotation (from driver end): counter clockwise
- Suction pressure: 642 psia
- Suction temperature: 45 F
- Discharge pressure: 879 psia
- Station compression ratio: 1.36:1 (single unit operation)
- Discharge temperature: 95 F
- Rated volume: 4,395 cfm, or 312,000,000 scfd
- Rated head, ft-lb/lb: 12,840
- Rated rpm: 6000
- Rated horsepower: 4980

Ten years ago, in 1947, Texas Eastern Transmission acquired from the government the War Emergency Pipelines, the Big Inch and Little Inch, and began converting them to gas transmission service. From the original 3182 miles thus acquired the system has grown to a total of 5700 miles and expansion is still in progress. Texas Eastern has been a progressive and expanding company from the beginning, and the highlights given here of typical stations are indicative of that progressive attitude and willingness to try new methods in desgn and operations. ★

New Metering Concept

Vortex-Velocity Type Flowmeter

Is a directly integrating device,
and gross volume flow is instantaneously obtained
from counter on meter
only a single correction needed for net volume

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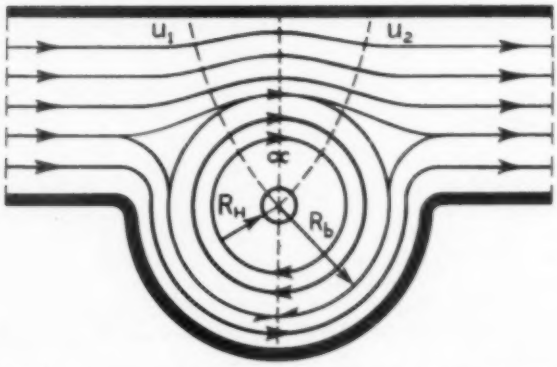


FIG. 1. Diagrammatic illustration of flow pattern in a Vortex-Velocity flowmeter.

FIG. 2. Typical small Vortex-Velocity type meter for 2-in. pipe, with direct reading mechanical totalizer.

DURING the last few years considerable practical experience has been obtained with a flowmeter of an entirely new basic type, viz. the Vortex-Velocity meter, and this meter is suitable for gas as well as liquid measurement.

The word, Vortex-Velocity, has been coined to denote this new type of inferential flowmeter in which a vortex is deliberately created and maintained and its peripheral motion locked to the *velocity* of the fluid stream to be measured. By giving certain proportions to the internal structure of such a dynamic fluid arrangement, a linear relationship can be established between the number of revolutions of the vortex in the pipe and the fluid velocity through the pipe. A true and accurate volumetric is thus obtained.

Structure

A meter of this type consists simply of a piece of pipe, generally of slightly smaller diameter than the pipe in which the meter is installed, and further of a dissymmetry in that pipe, in which a vortex is created and maintained. Fig. 1 illustrates the configuration diagrammatically.

Although the basic fluid dynamic structure of this flowmeter is simple, the detailed operation is quite intricate. During the approximately eight years of development that have been carried out with this meter, new light on the workings of the device have several times forced reconsideration of salient characteristics of its behavior. Although presently a meter has been created that has remarkable new features and is quite accurate, it is believed that there remain opportunities for continued refinement.

Features

There are two features of this meter that stand out in comparison to orifice type meters, which are so widely used in gas measurements. First, it constitutes an integrating meter that measures volume directly; the number of revolutions that the rotor of the meter makes is directly proportional to the total flow that has passed through the meter. Secondly, the output of the meter has a linear relationship to the flow and not a parabolic relationship. This, of course, allows great accuracy to be obtained.

By connecting a tachometer to the rotor output shaft, the device immediately becomes a rate flow indicator. If the tachometer is of the well-known electrical type, the meter can be used to remotely control and regulate other devices connected with the operation of the pipeline.

Presented before Short Course in Gas Technology sponsored by Southern Gas Association at Texas A & I College, Kingsville, Texas, May 29 to 31, 1957.

Gas or Liquid

The Vortex-Velocity flowmeter is a fluid flowmeter and will measure gases equally well as liquids. In fact, the performance of a meter of this type is the same, for example, for air as for water. The only limitation for the use with low density fluids is, as would be expected, that the output load on the rotor shaft must be held within the limits imposed by the lower energy content of the flowing gas as contrasted with the flowing liquid.

The present paper deals exclusively with a recent series of field tests made with this meter on a gas pipeline of the Gulf Interstate Gas Company at Catlettsburg, Kentucky. Before relating the results, a short theoretical analysis of the internal operation of this meter will be given.

Conception of Operation

Operation of the Vortex-Velocity flowmeter would seem to be based on the discovery of certain dynamic principles of fluid flows that can be treated mathematically. It can thereby be shown that it is possible to measure flows by measuring the velocity of *one* flowline only. Reduction to practice further shows that a flowmeter can be built on such principles that it is unusually accurate and responsive, and provides other new and obscure, or unforeseen, results and advantages. Because we are here dealing with the engagement of two flows, it becomes apparent that this type flowmeter will not be affected by wear and tear of the moving parts because such parts play no primary role in the system.

The principle of the Vortex-Velocity flowmeter is based on the coupling together of two types of flows, which then form one geometrical system with direct and well-defined relationship between the flow velocities of each. Thus, it is only necessary to measure the flow velocity of one flow line in either branch to know the corresponding velocity of every other flow line.

In the Rotron flowmeter the two types of flows are *main flow,* which has its source and sink outside the meter, and a *free vortex,* which is entirely confined within the walls of the flowmeter. Physically, the meter, according to one simple illustrative embodiment of the invention, comprises a conduit in the shape of a pipe and a semicylindrical cavity, called the *vortex chamber.* (See Fig. 1.)

When fluid flows through such an arrangement as shown in Fig. 1, there is a possibility that a variety of flow patterns will occur, all mathematically substantiated, though not necessarily stable. One would expect that the flow lines upon entering the cavity would expand into it without the presence of a vortex. At first glance this would seem to be the flow pattern of highest stability. This is not so, however. At the normal rate of fluid flow through pipelines, the Reynolds number is sufficiently high that the flow is not a laminar but a turbulent one. In other words, there are always present in the flow small vortices and in some cases even corkscrewing flow patterns. When these vortices enter the vortex chamber, they naturally *expand* into one or more large size vortices. Fig. 1 shows a vortex with the main flow enveloping it from both sides.

The angular velocity of any vortex flow line is directly proportional to the linear velocity of the main flow. Integration over the cross-section of the main flow will give us the flow of fluid through the flowmeter. It is then necessary to measure the revolutions of one flow line in the vortex to obtain either the rate of flow or totalized flow over a certain time, through the meter, irrespective of the changes in the rate of it. The introduction of a squirrel cage wheel into the cavity finally solved the problem of maintaining stable dimensions of the vortex over a wide range of flow rates. Thus, flowmeters have been realized that maintain their accuracy over a flow range of 20 to 1.

An outstanding characteristic of this type of meter is that the calibration of the meter is inherent in its dimensions rather than being dependent on tightness of fluid compartments, as in positive displacement meters in which calibration changes with degree of leakage. The Vortex-Velocity meter therefore retains its calibration throughout its life and is not affected by wear and tear.

The Authors

J. Constant van Rijn

Bohumir Larys

J. C. van Rijn is president of Rotron Controls Corporation and president and a director of the Rotron Research Corporation, Woodstock, New York. Born in Holland he came to the United States in 1941 as chief engineer of the radio communications department of Philips Export Corporation, New York City. Later he was consultant on communications for Netherland Purchasing Commission in New York and from 1944 to 1949 was a consulting engineer with headquarters in Woodstock. It was in the latter year that he formed the Rotron Manufacturing Company.

Bohumir Larys, chief electrical engineer and physicist for Rotron Research Corporation since 1955, received a degree in electrical engineering from the Czech Institute of Technology, Brno, Czechoslovakia, in 1934. He was granted a Gottshall scholarship from Lehigh University for post-graduate study in 1937 and received an MS degree in 1939. From 1939 to 1942 he completed 80 percent of the work required for a PhD. He worked for Westinghouse, 1939-40, and Diehl Manufacturing Company, 1942-55.

Mathematical Principles

Free vortex can occur in both compressible and incompressible fluids. The velocity of such a vortex at any point is defined by the following equation:

$$v = \frac{c}{r} \quad \ldots\ldots (1)$$

c = a constant having a direct relationship to the strength of the vortex

r = radius of any flow line.

Equation 1 shows that a vortex cannot exist at the center but that a void will occur, the radius (R_v) of which is determined by vapor pressure of the liquid and by outside boundary pressure of the vortex. Applying Bernoulli equation to the vortex, the static pressure at any point is expressed by Equation 2:

$$P = P_b - \frac{\rho c^2}{2g}\left(\frac{1}{r^2} - \frac{1}{R^2_b}\right). \quad (2)$$

P_b = static pressure at the external boundary of the vortex

R_b = boundary radius

ρ = specific density.

The Bernoulli equation will be satisfied for compressible fluids, such as gases, only when Boyle's law is applied to it.

$$PV = RT \quad \ldots\ldots (3)$$

$$\frac{TR}{W_m} + \frac{c^2}{2gr^2} = \text{const.} \quad \ldots (4)$$

W_m = molecular weight of the gas.

Equation 4 shows that the temperature decreases toward the center of the vortex and that at some point liquefication would have to occur if the vortex were properly constructed.

There are friction losses within the vortex that can be expressed by Equation 5:

$$W_f = 4\pi\,\mu\,lc^2\left(\frac{1}{R_v^2} - \frac{1}{R_b^2}\right). \quad (5)$$

μ = absolute coefficient of viscosity

l = axial length of the vortex equal approximately to the width of the squirrel cage wheel.

These losses, plus the mechanical losses in bearings, couplings and in required output torque to drive registering and indicating instruments, are sustained by a shunt flow into the vortex, which will add a radial velocity component to it.

$$v_r = \frac{c_2}{r} \quad \ldots\ldots (6)$$

c_2 = a constant having a direct relationship to the strength of the shunt flow.

Equation 1 and 6 are identical in their structure and, therefore, the char-

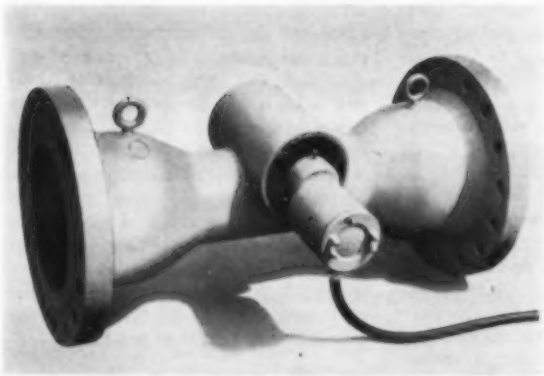
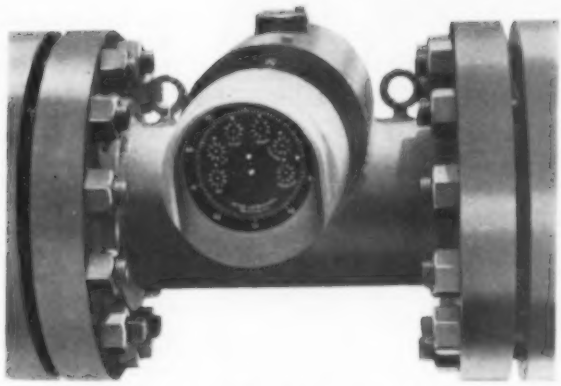


FIG. 3. Typical large Vortex-Velocity type meter for 10-in. pipe, shown with Selsyn transmitter mounted on one of its two magnetic output couplings.



Vortex-Velocity flowmeter with a 6-in. diameter throat, used in the tests described in the text.

acteristics of the vortex are not distorted by the addition of the shunt flow.

The finite height of the squirrel cage blades does not alter the structure of the vortex and, therefore, we shall think of it as an infinitely thin rim of radius R_w.

The vortex flow line next to the rim will have velocity:

$$v = 2\pi n R_w = \frac{C}{R_w} \quad . \quad . \quad (7)$$

n = revolutions per second of the wheel

$$C = 2\pi n R_w^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8)$$

Coupling of One-Dimensional Laminar with Vortex Flow

When two flows are coupled together, there is a region where both flow velocities can be defined by one equation common to both of them. The rate of the main flow can then be obtained by integration over any cross-section. It can be shown that the integral is a function of geometrical dimensions only and that it contains a constant:

$$\frac{v_o}{C} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

v_o = flow velocity of the main flow.

The rate of the main flow is expressed by Equation 10:

$$q = cI_q \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

I_q = integral function of dimensions only and invariable of the flow velocity.

Substituting for c from Equation 8, we obtain:

$$q = K_n \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

Meter constant: $K = 2\pi R_w^2 I_q$

Equation 11 expresses the essential linearity of the Vortex-Velocity flowmeter and also that it is a pure volume meter independent of viscosity and specific density. Totalized flow can be obtained by integrating in time of Equation 11:

$$Q = K\int_0^t ndt \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (12)$$

Effect of Viscosity and Mechanical Losses

The reduction of the Vortex-Velocity principle to practice shows that there is a certain dependence on viscosity that, however, can be eliminated by proper design.

Theoretical considerations of the shunt flow pressure drops show that the effect of rate and viscosity is only secondary and, therefore, can be eliminated as already stated above.

Catlettsburg Tests

A meter with a 6-in. diameter throat was placed in series with an orifice plate flowmeter on one of a number of parallel branches of a manifold. The flow through the particular branch was regulated by the manipulation of a valve to obtain mercury column readings at the orifice plate of 10 to 100-in. Hg. With the aid of a stop watch, the number of revolutions of the rotor of the Vortex-Velocity meter was read over a one-minute time interval. The flowrate measurements thus obtained by means of the orifice meter on one hand and the Vortex-Velocity meter on the other hand, duly corrected for the usual factors, were found to be in agreement within 0.01 to 0.3 of 1 percent. This was over a flowrange from 23 Mcf per day to 95 Mcf per day, the latter figure being the upper limit of the orific meter used but not of the Vortex-Velocity meter.

After the completion of these tests, the Vortex-Velocity meter was observed in continuous operation on this gas line over several weeks and the long range correspondence between the

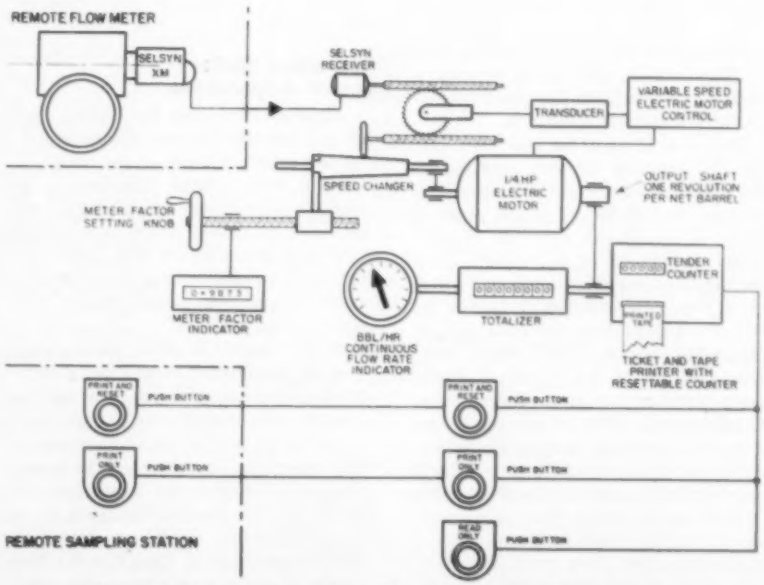


FIG. 4. Remote registration system with combined-meter-factor correction.

FIG. 5. Typical assembly on station console of rateflow indicator, totalizer, combined-meter-factor adjustment, and electrical ticket printer.

orifice plate readings and the Vortex-Velocity meter readings was found to lie within limits of roughly 0.1 of 1 percent. From these correspondence figures it should not be inferred that the accuracy of the Vortex-Velocity meter is of the order of a few tenths of one percent. On the contrary, from experience so far gained with accurate calibrations on Vortex-Velocity meters, it appears that the possibility should not be excluded that the accuracy of the new meter is greater than the accuracy of any measuring apparatus with which it has so far been tested, in other words, the meter repeats a calibration within the degree of resolution of the measuring system.

Be this as it may, the one outstanding characteristic of this new meter that should be brought forward in connection with its use in gas pipeline service is a quite different one. Whereas the use of orifice plate meters gives readings that require the application of some five different meter factors as well as a square root operation and an integrating operation to obtain total flow, the use of the Vortex-Velocity meter requires no such cumbersome manipulations. First of all, the meter in itself is a directly integrating device, and a total gross volume flow is directly and instantaneously obtained from the counter on the meter. The meter reading of volume flow requires only a single correction from gross volume to net volume, for which operation simplified formulae have been derived. This inherent simplification in gas volume measurement would appear to forecast a great future for the Vortex-Velocity type of flowmeter in gas measurement, provided other practical requirements can be satisfactorily met.

New Meter Readout System

Remote readout of flowmeter operation in convenient office localities rather than direct readout at an open-air platform is a feature not only of great convenience and of economy, but also one that is apt to lead to great accounting accuracy. The Vortex-Velocity meter as made by Rotron Controls Corporation is fitted with two magnetic output couplings to which a variety of direct and remote readout equipment can be applied.

In one arrangement a 60 cps electric selsyn transmitter is applied to one of these two outputs (see Fig. 3), and the transmitter in turn is connected to a remote receiving selsyn motor in the station office. This receiving selsyn now turns in synchronism with the flowmeter and constitutes the input of a unique synchronous torque amplifier shown diagrammatically in Fig. 4. The torque amplified controls a powerful, variable-speed electric motor from the output of which a variety of readout equipment is driven, as may be required by the practice in any particular pipeline station. (See Fig. 5.)

Following the diagram of Fig. 4, it will be seen that the selsyn receiver causes an imbalance in the differential screw mechanism, which imbalance in turn is transmitted to a transducer, which controls the speed of the powerful central electric driving motor, thereby completing the servo loop and stabilizing the circuit at the required speed level.

Combined Meter Factor Adjustment

Interposed between the output motor and the synchronous torque amplifier is a speed changer of the infinitely variable type whose function is to inject into the computer, whenever required, a combined meter factor. This combined meter factor will cover any necessary corrections for temperature, viscosity, and rate, in accordance with best pipeline practice.

Meter factor, if other than unity, must be established from rate as indicated on the rate-flow indicator on the console from viscosity by specification or test and from product temperature. The meter factor setting of the speed changer is effected by handwheel or electrical drive and is indicated by a digital, five-figure, counter mounted on the instrument panel. (See Fig. 5.) The setting is reproducible to within four decimal places. Having set into the computer the proper factors, the output motor now turns at a rate of one revolution for every *net* unit of product, and both the totalizer and the ticket printer record factored and temperature corrected net units.

The output motor can drive a variety of instruments, which may be chosen to best suit the practice of any station and which normally are combined onto a console. The rate indicator shown mounted on the console in Fig. 5 displays continuously the flowrate in the pipeline in *net* units of product.

No "On-the-Fly" Reading or Printing

A further unique feature of this circuit is that any and all readout and printout operations can be done with the main output shaft at rest. Whenever a counter is to be read or a printer to be operated, the corresponding pushbutton automatically stops the central output motor temporarily. During this interval of approximately 30 seconds, readings are mechanically stored and memorized in the differential mechanism and are again transferred to the counters upon the automatic reclosing of the circuit.

Electric Remote Printer

Besides a totalizer and batch counter and a continuously indicating rate flow indicator, all reading in net corrected units, the console is normally fitted with a ticket or tape printer. By manipulation of pushbuttons, this printer either can print the momentary total or print and reset to zero. The latter feature will be used when filling tanks or at tender changes in a products pipeline and it is noteworthy that such printing can be initiated from any desired location, for example at a manual valve station, simply by branching an electric pushbutton to that location.

Conclusion

It is believed that this new integrating type flowmeter, together with the remote readout system and the combined-meter-factor correcting device, holds a promise for greatly improved and simplified metering of gases and liquids.

Acknowledgment

The Rotron Controls Corporation is much indebted to the Gulf Interstate Gas Company of Houston, Texas, for their cooperation in allowing the referenced tests to be performed at their Catlettsburg pipeline terminal and expresses their sincere thanks to Norman Blundell, chief engineer; Bruce J. Caldwell, measurements superintendent, and Ralph Williams, station superintendent. ★ ★ ★

Compressibility Factor Charts

For Natural Gas Calculations

Carl Gatlin
The University of Tulsa

The gas law applied to the behavior of natural gases is most commonly expressed as:

(1) $pV = znRT$

where:

- p = pressure, absolute
- V = volume
- n = number of mols
- R = gas constant
- T = absolute temperature
- z = compressibility (also called deviation) factor to account for the difference between actual and ideal gas volumes.

The value of R is dependent on the system of units used as listed in Table 1.

Table 1. Values of the Gas Constant, R, for Some Commonly Used Units of p, V, and T.

p	V	T	R
lb per sq in.	cu ft	°Rankine	10.73
lb per sq ft	cu ft	°Rankine	1545
atmospheres	cu ft	°Rankine	0.7302

Determination of "z." Theory and background of compressibility factor determinations is completely covered in various texts. [1,2] Briefly, the values of "z" for natural gas mixtures have been experimentally correlated as functions of pressure, temperature, and gas gravity.

Compressibility factors for natural gases are functions of pressure, temperature, and composition. The latter variable, composition, must be known in order to compute the molal average critical (called pseudo critical) pressure and temperature. In many cases the chemical analysis is not available and pseudo critical properties must be estimated from the gas gravity, which is normally known. Several correlations relating gas gravity to pseudo critical pressure and temperature have been published. [3,4,5]

Curves published here have been developed from the gas gravity vs pseudo critical property data of Brown, et al., [4] and the compressibility factor vs reduced property data of Standing and Katz.[3] Similar curves based on a different correlation have been presented by Buthod.[6]

In these curves z may be obtained directly for a given gravity, pressure and temperature. Values at intermediate gravities may be easily interpolated. Curves are provided for condensate and miscellaneous casinghead and dry natural gas) gases for gas gravities above 0.65. Due to difference in composition of the two gases, there is a significant at temperatures below 200 F where source of gas is unknown, values for miscellaneous gas should be used.

Example Problems

1. A cylindrical tank contains miscellaneous 0.80 gravity natural gas at 2500 psia and 100 F. The volume of the tank is 10 cu ft. How many lb of gas are in the tank?
(Note: Molecular weight of air is 29 = number of mols)

Solution:

$$n = \frac{pV}{zRT} = \frac{(2500)\,(10)}{(0.67)\,(10.7)\,(560)} = 6.2 \text{ lb-mols}$$

Weight = 6.2 x 0.80 x 29 = 144 lb

2. 1000 std cu ft are released from the tank. The final tank temperature is 60 F. What is the final tank pressure?
(Note: At standard conditions, one mol equals 379 cu ft).

Solution:

$$n_{\text{remaining}} = 6.2 - \frac{1000}{379} = 3.6 \text{ mols}$$

$p = \frac{znRT}{V}$ but z = function of p, therefore the solution requires trial and error.

Assume (1) $p = 1500$, then $z = 0.581$, $\frac{p}{z} =$ 2580 (high)

(2) $p = 1300$, then $z = 0.681$, $\frac{p}{z} =$ 2100 (high)

(3) $p = 1250$, then $z = 0.627$, $\frac{p}{z} =$ 1995 (close enough)

$\therefore$ final p = 1250 psia

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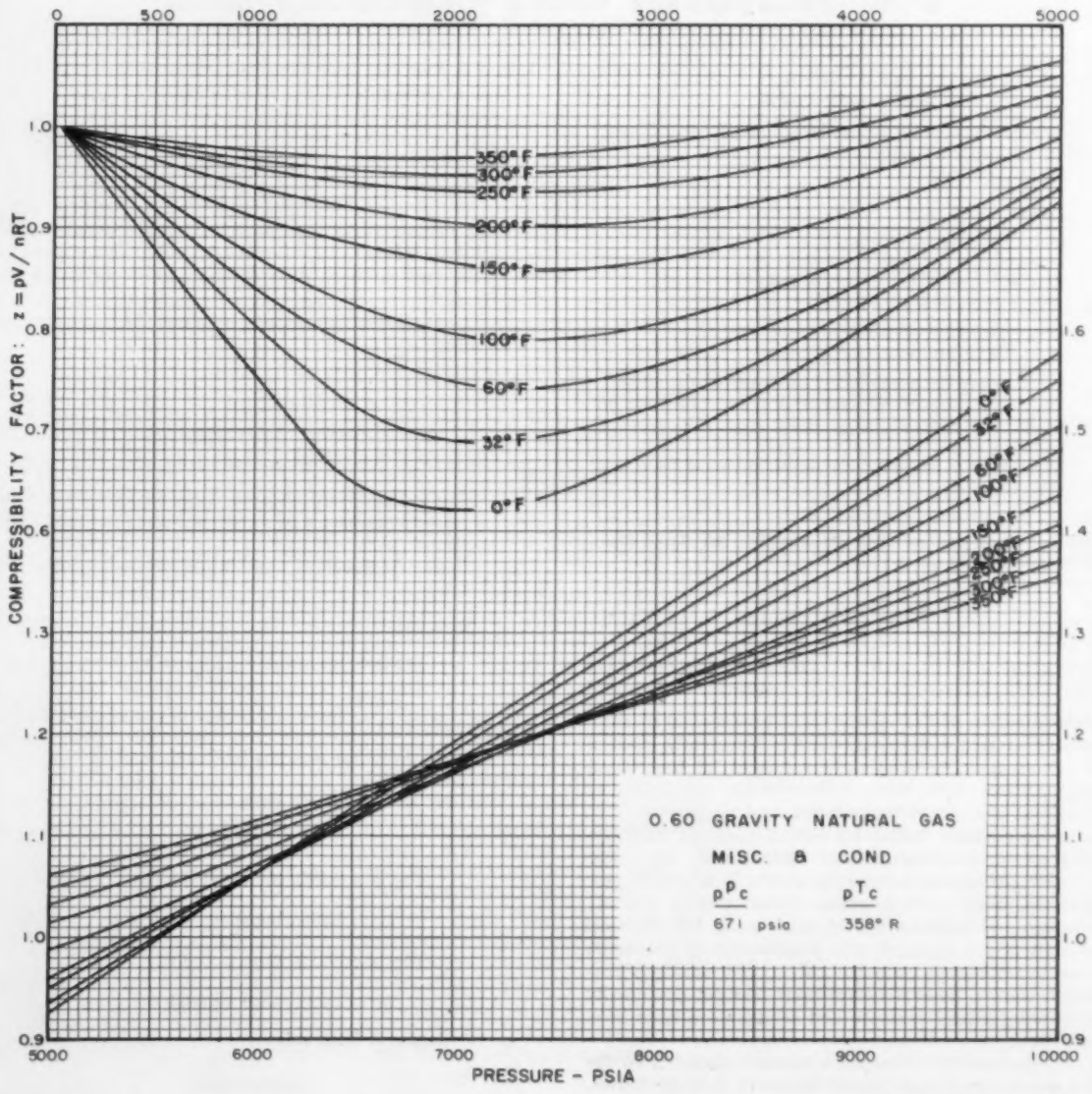
6. Paul Buthod, "Compressibility Factors and Specific Heats of Natural Gases," the *Oil and Gas Jour.*, September 8 and 28, 1949.

SIMPLIFIED COMPRESSIBILITY FACTOR CHARTS FOR NATURAL GAS CALCULATIONS

CHART 1



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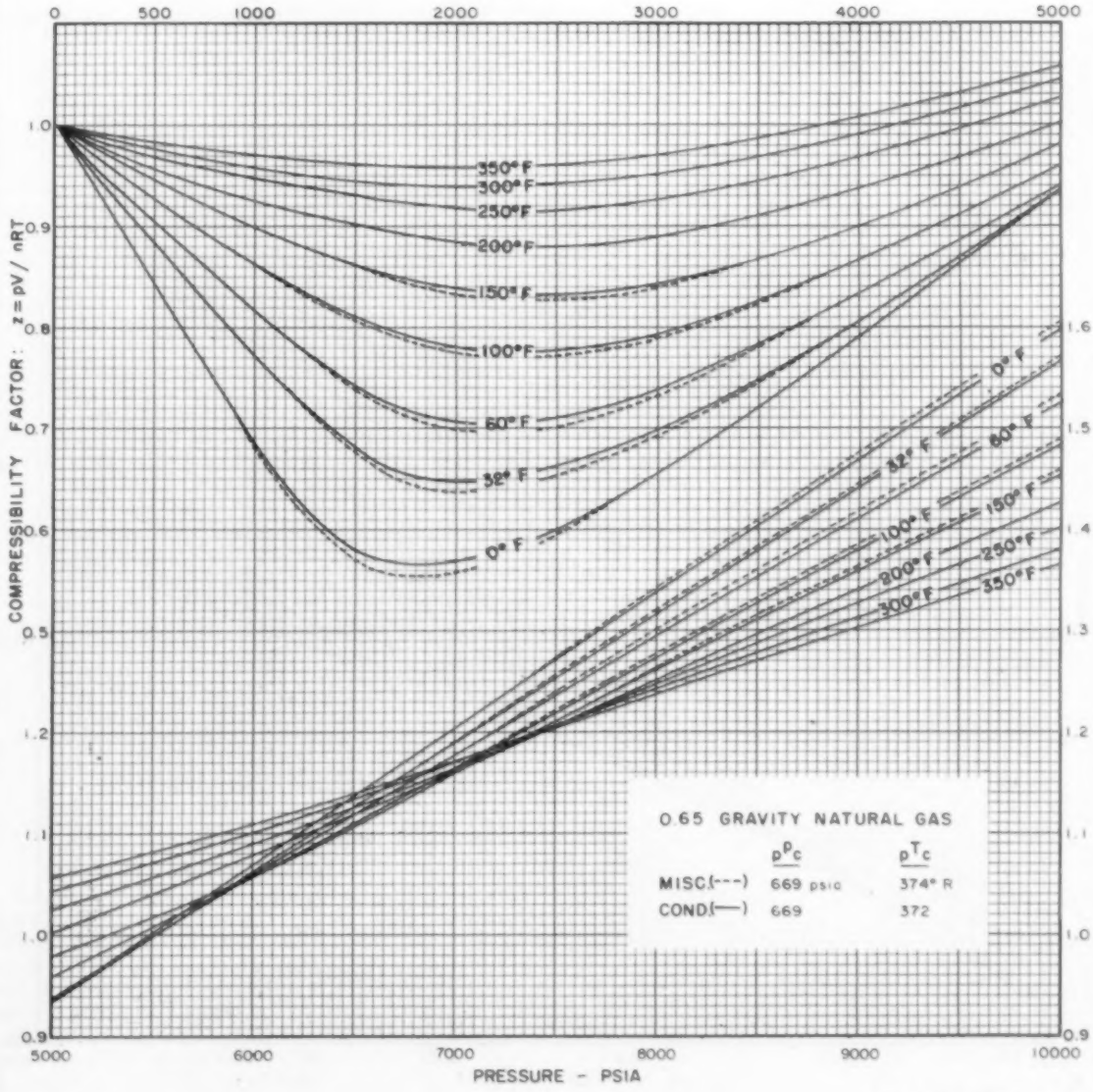
SIMPLIFIED COMPRESSIBILITY FACTOR CHARTS FOR NATURAL GAS CALCULATIONS

CHART 2



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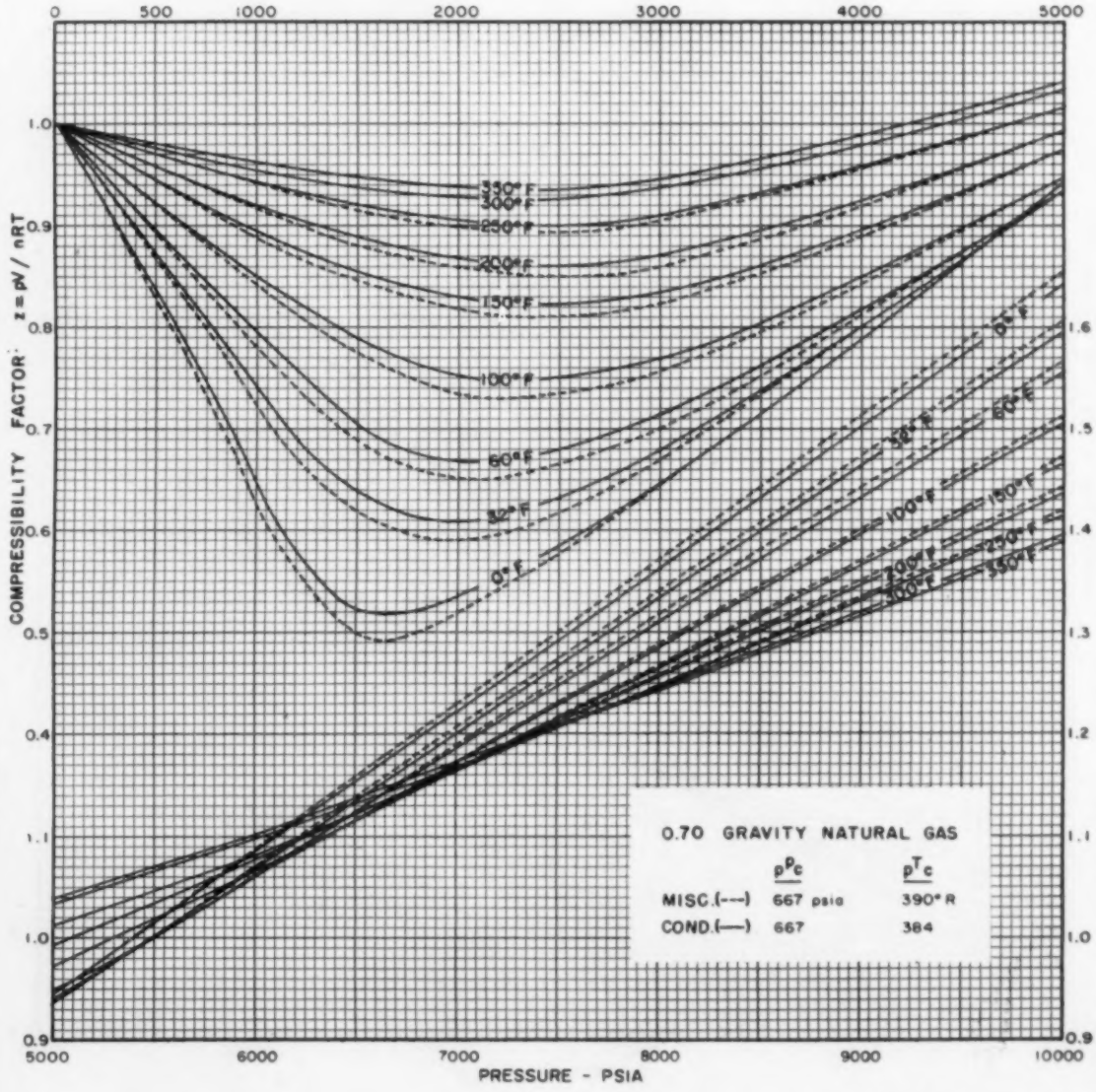
SIMPLIFIED COMPRESSIBILITY FACTOR CHARTS FOR NATURAL GAS CALCULATIONS

CHART 3



Carl Gatlin, University of Tulsa

Part 1

Bureau of Mines' studies in two fields result in conclusions regarding type of tests that will give best deliverability data

How Gas Storage Wells Behave

C. J. Walker, E. R. Corliss, J. S. Miller, and H. N. Dunning

U. S. Bureau of Mines, Petroleum Experiment Station, Bartlesville, Oklahoma

USE of natural formations as gas-storage reservoirs recently has become an integral part of the transmission of gas to the consumer. In 1953 the American Gas Association, through the Underground Storage Committee and Deliverability Problems Subcommittee, initiated a cooperative project with the Bureau of Mines on the deliverability of gas wells in storage reservoirs.

Six gas-storage reservoirs have been tested during cycles of injection and withdrawal in an effort to reach a better understanding of the principles of gas flow and gas-well behavior.

Preliminary results and correlations of these tests on the Ulan reservoir in southern Oklahoma and the Bridgeport reservoir in West Virginia are presented in this report.

Average depths of the formations used in these two gas-storage projects are about the same. Depth of the Bridgeport project is 1900 ft and that of the Ulan project is 2000 ft.

Wells of the two projects have been completed differently in that the producing string of the Bridgeport project is 5½-in. casing set about 50 ft above the storage formation with the exception of well B-2, which is completed with 7-in. casing. Approximately half of the wells have been shot. Wells of the Ulan storage have 7-in. casing set into the top of the storage and a string of tubing within the 7-in. casing, which can be used as a siphon in the event of liquid accumulation in the well.

About half of the Ulan storage wells have had hydraulic fracturing treatments. Both storage formations are of highly permeable sandstone. The Bridgeport formation is the "50-foot" sand of Devonian age and that of the Ulan storage is the Booch sand of Pennsylvanian age.

The prediction of gas-well behavior in storage projects is complicated by alternate injection and withdrawal of gas and by high rates of flow. At the same time, such predictions are simplified because of the high premeabilities of the reservoir rock, relatively low pressures and temperatures involved, and the dryness of the gas commonly encountered in storage projects.

The well known back-pressure equation, $Q = C\,(P_f^2 - P_s^2)^n$, originally was developed empirically from a large amount of field and laboratory data.[1] Several articles on the back-pressure test have appeared in the literature and have aided in a clearer delineation of the applications and limitations of this testing procedure.[2, 3] The "isochronal performance" method of Cullender,[9] one of the most important advancements in gas-well testing, results in curves that may be described by the usual back-pressure equation.

Relationship of the back-pressure equation to those describing viscous (streamline) flow has been generally recognized. Considerable work in this field, however, has caused serious doubt that equations based on viscous flow can describe the behavior of gas wells producing at high pressures or storage reservoirs with high injection and withdrawal capacities.

Isothermal viscous flow through a capillary can be described by the equation:

$$(vp) = (\pi d^4/128\mu L) \times \tfrac{1}{2}\ (P_1^2 - P_2^2) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

and turbulent flow by the equation:

$$(vp) = [(\pi^2 r_h d^4 RT/16\beta L) \times (P_1^2 - P_2^2)]^{0.5} \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Where:

- v = flow rate,
- d = capillary diameter,
- μ = viscosity,
- L = capillary length,
- r_h = hydraulic radius (cross-section/periphery),
- β = a friction factor,
- p = pressure,
- R = gas constant,
- T = absolute temperature,
- P_1 and P_2 = higher and lower pressures, respectively;

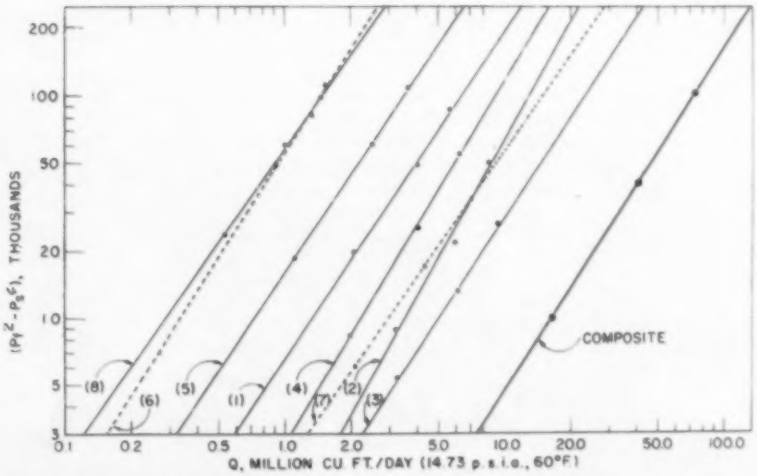


FIG. 1. **Conventional back-pressure curves** and composite curve for Ulan project. (Bottom-hole conditions, October 1954, average shut-in pressure: 400 psia.)

E. R. Corliss' present address: Southern Union Gas Company, Dallas, Texas.

Paper presented at Transmission Conference, Operating Section, American Gas Association, San Francisco, California, May 9, 1957, under title "Deliverability Tests on Gas-Storage Projects."

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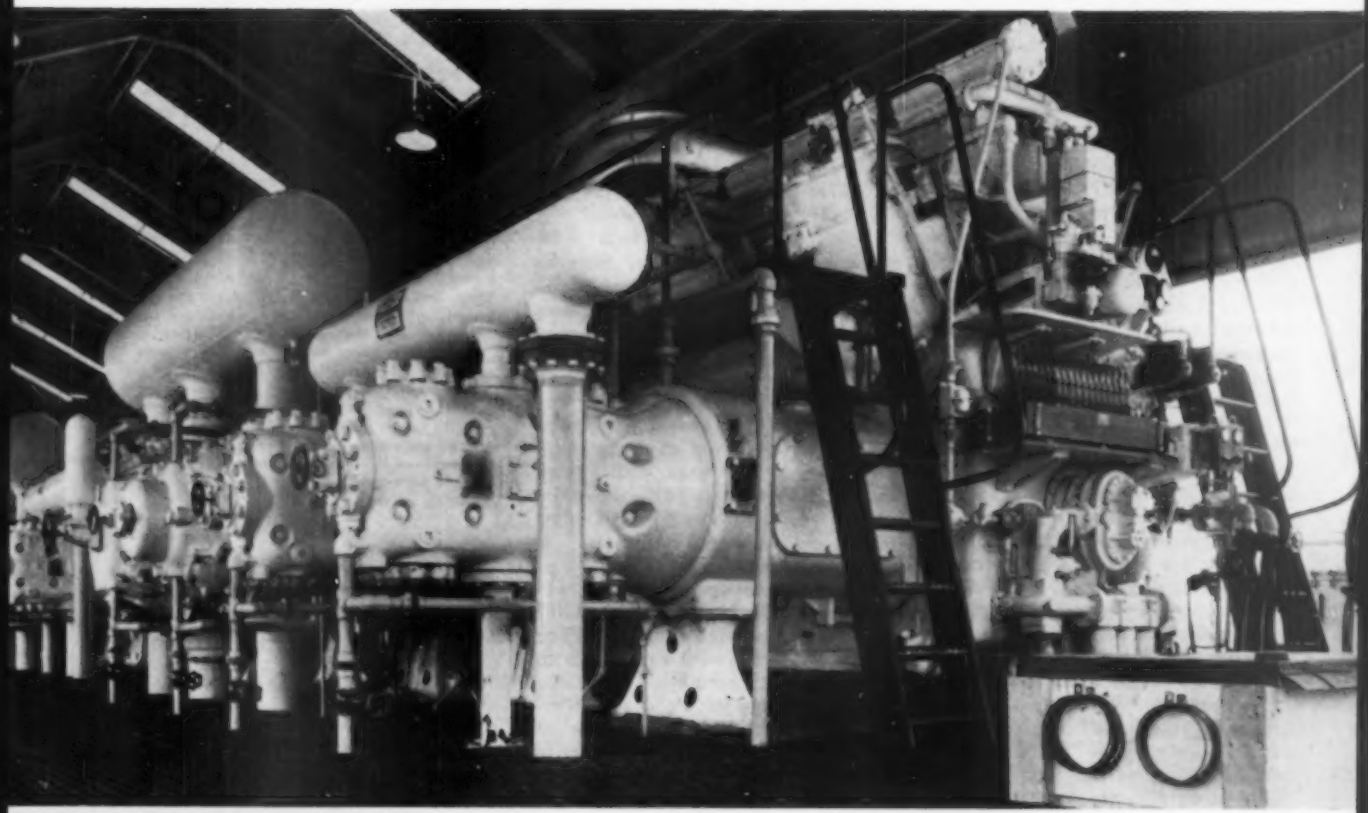

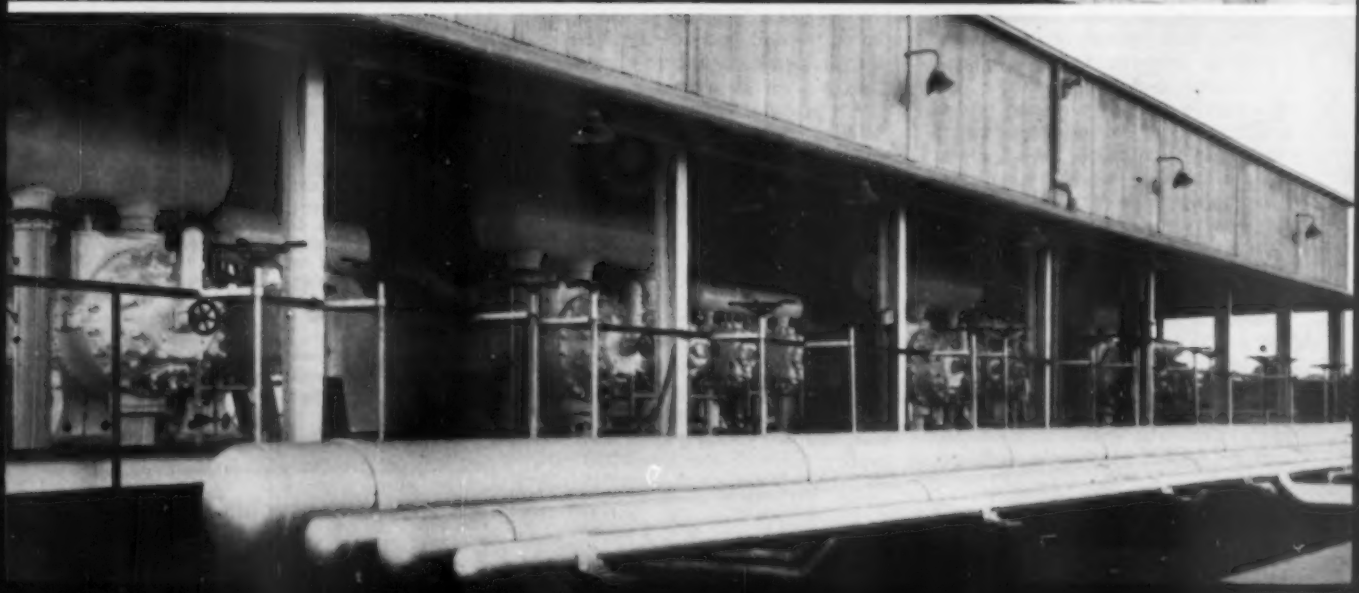

and the various constants and parameters of the equations are expressed in consistent units.[10]

The similarity of these equations to those describing flow through porous media is apparent. Grouping the constants of these equations as is done in arriving at the common permeability constant, the viscous flow Equation 1 becomes:

$$(vp) = k_1(P_1^2 - P_2^2) \quad . \quad . \quad (1a)$$

and the turbulent flow equation is:

$$(vp) = k_2(P_1^2 - P_2^2)^{1/2} \quad . \quad . \quad (2a)$$

Therefore, isothermal high-pressure gas flow, regardless of the Reynolds number,[10] can be expressed in an equation of the form:

$$Q = C(P_1^2 - P_2^2)^n \quad . \quad . \quad . \quad . \quad (3)$$

where "Q" is expressed as a flow rate, corrected to standard conditions of temperature and pressure. This equation is strictly applicable only to flow through a porous medium, where P_1 is the inlet pressure and P_2 the outlet pressure. Its application to a gas producing formation, where a changing drainage radius is involved, is theoretically less apparent.

Some theoretical calculations[11, 12] indicate that the rate of increase of the drainage radius is independent of the pressure drop. If this is so, each isochronal curve would be representative of a given radius of drainage and the above equations would be applicable. Innumerable field tests conducted by the flow-after-flow back-pressure method have given data that could be closely approximated by Equation 3. This fact is a considerable argument for accepting its theoretical, as well as practical, applicability.

The difference between viscous and turbulent flow appears as the value of the exponent "n" in Equations 1a and 2a, respectively. When viscous flow conditions prevail, "n" is equal to one and in turbulent flow "n" is equal to one-half. Houpert[11] reports calculations, which of necessity involve several broad assumptions, showing that turbulent flow seldom occurs in gas-producing formations. Instead, these calculations show that the flow rate may vary from that predicted by the streamline flow equation because of "end" and "jet" effects. These effects result in an energy loss and hence a decrease in the value of "n" in a manner similar to that observed in turbulence.

Barrer[10] states that the value of "n," in the systems in which Equations 1a and 2a are strictly applicable, determines whether streamline or turbulent flow is occurring. It also is evident that turbulence often occurs in the producing string. In any event, the decrease of "n" from unity represents an energy loss. The back-pressure Equation 3 describes gas flow in a manner that is theoretically and practically sound, although the value of "n" may be strictly constant only over a limited range of flow rates.

Procedures

Seven wells in the Bridgeport storage project and eight wells in the Ulan project were tested by the conventional (flow-after-flow) back-pressure method. The wells tested comprised about 80 percent of the wells in the Ulan project and the south pool of the Bridgeport project.

Series of tests were made during withdrawal and injection operations at widely different shut-in reservoir pressures. When possible, the wells of a storage project were tested simultaneously to approximate actual operating conditions. Each flow rate was maintained for two hours, a sufficient time to permit practical stabilization in these reservoirs. Wellhead pressures were measured with dead-weight gages during, and at the end of, each period.

Wells of the two projects were equipped with orifice-meter runs to measure the flow of gas in and out of storage for the evaluation of well performance and for inventory purposes.

Orifice-meter runs on the Ulan storage wells were of the parallel type, one for injection operations and one for withdrawal. They were equipped with a single Bristol static and differential pressure-recording gage with piping and valves that permitted the use of the gage to record pressure during both injection and withdrawal operations.

The orifice run of the original well (B-1) of the Bridgeport storage was equipped with a Metric Meter and differential pressure-recording gage. The rest of the wells were equipped with connections that permitted the use of a portable Barton-type static and differential gage, which was capable of measuring differential pressures up to and including 200 in. of water. These gages were calibrated with dead-weight pressure gages. Wellhead pressures and the corresponding flow rates were recorded, together with other pertinent data, on a well-data sheet.

At the end of the withdrawal test of the Bridgeport project, the wells were shut in at the wellheads overnight to permit pressure stabilization. Then back-pressure tests were made during injection of gas.

Wells of the Bridgeport project were tested in March 1955 and again in November 1956. The average shut-in pressures of the wells were about 150 and 500 psia, respectively. Wells of the Ulan project were tested in April and October 1954 when the average shut-in pressures were about 300 and 400 psia, and in February 1956 when the average pressure was about 310 psia.

The Authors

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In the 1956 tests of the Ulan project, four wells were studied by the isochronal performance method of Cullender,[9] in addition to conventional back-pressure tests during injection and withdrawal operations. In accordance with this method, the wells then were opened to successively greater flow rates for a two-hour period at each of three rates, and shut in between flow periods to allow the wellhead pressures to return to their original values. Flow rates and wellhead pressures were measured at quarter-hour intervals by the methods described above.

Conventional back-pressure tests of the four Ulan wells were conducted the day after the isochronal tests. The conventional test consisted of a series of three increasing flow rates maintained for two-hour intervals. Flow rates and wellhead pressures were measured and recorded at quarter-hour intervals for comparison with the results of the isochronal performance curves.

Major purpose of testing the gas-storage projects was to develop correlations by which the behavior of several wells could be predicted during actual withdrawal operations. Therefore, well performances predicted from conventional back-pressure tests and isochronal performance curves were compared to actual production figures. Points to be plotted on curves showing production performance were calculated from flow rates and flowing pressures measured at the well heads and by using the wellhead pressure of the nearest observation well as the shut-in pressure.

Back-pressure test results commonly have been calculated at bottom-hole conditions. Therefore, the results of these back-pressure tests were calculated at bottom-hole conditions, as well as at wellhead conditions. Shut-in bottom-hole pressures were calculated from wellhead pressures by the usual method[1] in which the weight of the static column of gas is added to the wellhead pressures to arrive at the bottom-hole pressures.

Flowing bottom-hole pressures were calculated by the method of Smith.[13] These calculations involved addition of the weight of the flowing column of gas to the wellhead pressure and, also, the pressure change caused by frictional resistance of the tubing or casing to flow. The frictional effect was evaluated by the method of Smith and coworkers.[14, 15]

Results and Discussion

Conventional back-pressure tests. The results of two series of tests made in April and October 1954 during withdrawal operations on eight wells of the Ulan storage project are summarized in Table 1. Tabulated values were calculated by the least squares method[5,16] with a calculator or digital computer.

Average shut-in pressures were about 300 and 400 psia, respectively, during these tests. Although the values of the coefficient "C" of the gas-flow equation vary widely (150-20,400), the values of "n" fall in a fairly representative range (0.570-0.790), averaging 0.690 for both bottom-hole and wellhead conditions.

The results of two series of tests in which a group of wells of the Bridgeport project were tested simultaneously in 1955 and 1956 when the shut-in pressures were about 150 and 500 psia, respectively, are summarized in Table 2. The range of "n" values is similar to that of the Ulan project and is within the range of a large number of values

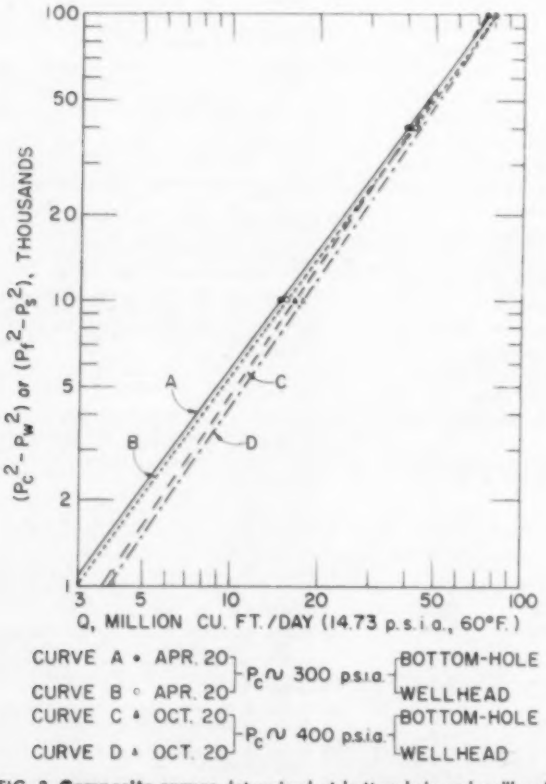

FIG. 2. **Composite curves determined at bottom-hole and wellhead conditions from conventional back-pressure curves of wells in the Ulan project (1954).**

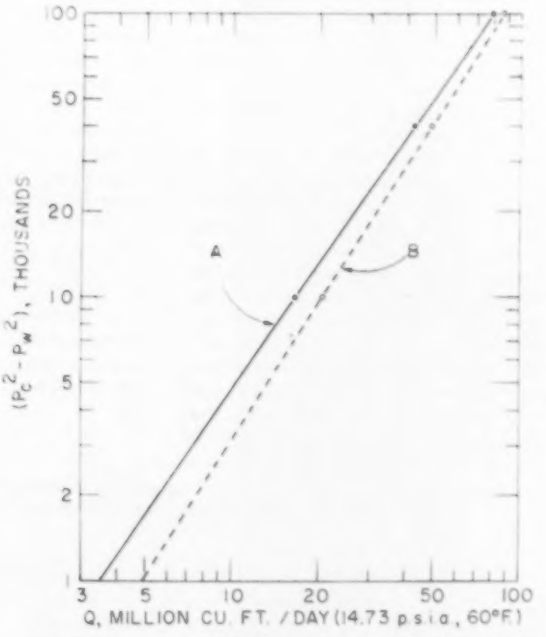

FIG. 3. **Comparison of composite back-pressure curves for Ulan (Curve A) and Bridgeport (Curve B) projects, during withdrawal operations.**

reported by Rawlins,[1] and by Haymaker.[4] The back-pressure curves for the wells of the Ulan project (October 1954, shut-in pressure about 400 psia, bottom-hole conditions) are shown in Fig. 1.

Composite curves for the wells of each reservoir were drawn by the method of Bureau of Mines Monograph 7.[1] The values of "Q" corresponding to selected values of $(P_f^2 - P_s^2)$ for each well were calculated from the data of several back-pressure curves, added group by group to obtain a composite value of "Q" corresponding to each value of $(P_f^2 - P_s^2)$. The parameters of the composite curves were calculated from these data points and are summarized in Tables 1 and 2. This method does not account for the different values of $(P_f^2 - P_s^2)$ that result in the several wells if they are connected to a common pipeline. It has the advantage of simplicity, however, and was favored by Ferguson who made an extensive study of the problem.[5]

As indicated by Ferguson,[5] composite curves may not be straight lines if they are formed from curves of different slopes. Slopes of the curves for the wells within each of these two projects are not identical but fall within a narrow range. Furthermore, the composite data plot as essentially straight lines within the ranges of pressures and flow rates studied. Therefore, within the above limitations, these curves may be considered good approximations of the reservoir behavior.

The composite curves at bottom-hole and at wellhead conditions for each of the two test series on the Ulan reservoir are shown in Fig. 2. The wellhead curves differ less from the bottom-hole curves, for the same test, than do the bottom-hole curves from one test to the next. This observation generally applies also to the curves for single wells and is corroborated by similar comparisons of the Bridgeport test results (see Table 2). It appears, therefore, that there is little reason for calculating the results of back-pressure tests on a bottom-hole basis to determine the deliverability characteristics of wells in storage projects in relatively shallow and highly permeable formations. The capacities of gas wells determined at bottom-hole conditions are of importance in determining the best (within economic limits) methods of completing wells and are of greater importance for deep, high-pressure reservoirs. Once a project is completed, however, the practical values of well-behavior constants generally are those determined by wellhead-deliverability studies.

The average composite curves, at wellhead conditions, of the Ulan and Bridgeport reservoirs are shown in Fig. 3. Corresponding curves calculated for bottom-hole conditions are nearly identical with these. The curves for the two projects are not widely different. The Bridgeport curve is displaced toward higher values of flow rate at the lower pressure differences but because of its lower "n" value, the curves approach each other at higher pressure differences.

Groups of curves such as those shown in Fig. 1 illustrate a point that is worthy of special attention. It has long been recognized that "absolute open flow" values for gas wells are often questionable because they are determined by graphical or mathematical extrapolation far beyond the range of the test. The "C" values, like "open flow" values, are determined by extrapolation that often is unjustified. For example, Well U-3 is the best well in the Ulan project, judged by actual performance and consideration of Fig. 1. Yet in the 1954 tests its average "C" value was 8300, considerably less than that of Well U-2 (15,900), and only slightly greater than that of Well U-4 (6000).

It would appear that a reasonable method for comparing well behaviors within a reservoir, or perhaps between similar reservoirs, might be to compare the "Q" values at some base value of $(P_c^2 - P_w^2)$ close to or within the normal test range. A representative base value of $(P_c^2 - P_w^2)$ for the two reservoirs tested at both high and low formation pressures would be 10,000. This "Q_{10}" value may be read directly from the back-pressure curve or calculated from the familiar forms of the straight line equation.[16] Because little or no extrapolation is involved, the "Q_{10}" value can be read from the back-pressure curve about as accurately as are graphical values used to determine the "n" value. If the "n" value is determined by the least squares method, the slightly larger effort of calculating the "Q_{10}" value would be justified. The "Q_{10}" values of the several wells are compared in Table 3.

TABLE 1. Summary of "n" and "C" Values[1] for Back-Pressure Curves of 8 Wells and Composite Curves, Ulan Gas-Storage Project.

	Individual Wells		Composite
	Range	Average	
Wellhead, April 1954[2]			
n	0.615–0.770	0.720	0.705
C[3]	250–11,500	3,400	24,100
Bottom-hole, April 1954			
n	0.650–0.790	0.720	0.710
C	150–7,700	2,800	21,300
Wellhead, October 1954[4]			
n	0.570–0.715	0.660	0.655
C	450–20,400	6,300	43,600
Bottom-hole, October 1954			
n	0.570–0.710	0.660	0.650
C	400–18,800	5,800	40,200

[1]Equation 1.
[2]Shut-in pressure, 300 psia.
[3]Cubic feet per day (14.73 psia, 60 F).
[4]Shut-in pressure, 400 psia.

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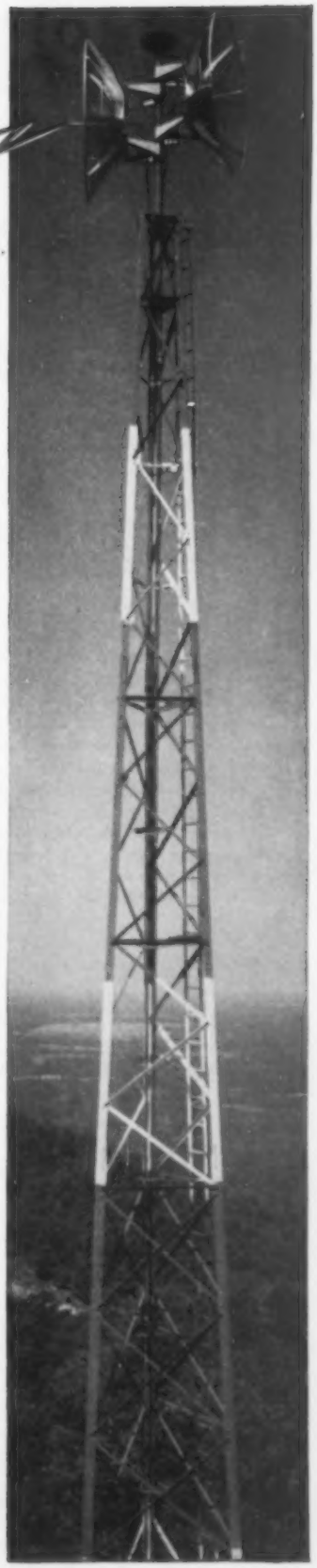

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Part 2: Selecting a Crossing Site

HOW TO ANALYZE THE FORCES THAT ACT ON

River Crossings

Those caused by currents and turbulence are the least understood — and the most frequent causes of trouble

Leo M. Odom
Pyburn & Odom Consulting Engineers
Baton Rouge, Louisiana

THERE are dozens of factors that must be taken into consideration in the designing of a pipeline river crossing; failure to make proper allowance for any one of these can result in failure of the line. Because of the critical nature of the crossing and the difficulties in repairing it in short order, this is one of the most serious problems ever to cross the desk of the chief engineer or consulting engineer saddled with the responsibility of making the many decisions inherent in the design of a system.

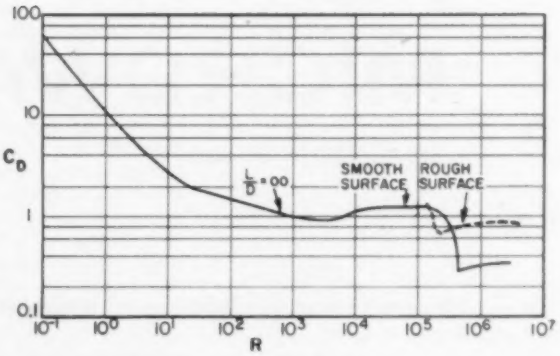
The most important factor in many rivers is the location of the crossing site. This is especially true of rivers that flow in beds of their own alluvium of which the lower Mississippi River is typical. This was discussed in the first part of this series.

Other factors that must be considered in the design of the pipeline river crossing are:

The effects of buoyancy,
Stream currents,
Stream turbulence,
Scour and fill of the stream bed,
Bank recession,
Debris and sand movement,
Temperature changes,
Anchoring of boats,
Dredging,
Corrosion,
Corrasion and
Attack by marine organisms.

Of these factors the characteristics of the external hydrodynamic loads caused by currents and turbulence, are probably the least understood and are also the most frequent causes of trouble. Pipeline crossings of rivers, whether submerged or aerial, present basically the problems of a cylinder submerged in a moving fluid. Both aerial and submarine crossings are thus subject to several types of dynamic loads derived from the movement of the surrounding fluid. These loads differ in their magnitudes and relative importance in accordance with the magnitudes of the density and velocity of the surrounding fluid.

Perhaps the most readily conceived of these loads is "drag," or the downstream force resulting from impingement of the current or wind on the pipe.



Drag coefficients for circular cyclinders

The second type of dynamic load is a periodic alternating load which acts perpendicular to the primary direction of the current and tends to induce vibration or "flutter" of the pipe. This type of load occurs only at certain combinations of stream velocity and pipe diameter but is undoubtedly the most frequent cause of failure of pipelines suspended in flowing water. This fact is due to the repetitive character of the loading which causes "fatigue" in the metal.

A third type of load resulting from the dynamic effects of the moving fluid is that resulting from the "turbulent velocity fluctuations" of the passing flow. Less is known of the details of this phenomenon than of the two foregoing load sources. Briefly, it results from the fact that in turbulent flow the instantaneous velocity at a point varies constantly and widely with time. There are irregular velocity pulsations in the stream. These velocity pulsations result in variations in the total pressure acting at the point and in variations in the differences in pressure between adjacent points. The pressure differential between a point in a relatively still portion and a point within a more rapidly moving portion of the fluid results in forces acting toward the point where the higher velocity, and hence the lower pressure, is found.

FUNDAMENTAL CONCEPTS OF HYDRAULICS

Before we take up these three types of loads individually, let's briefly review some of the fundamental concepts of hydraulics that are pertinent to the analysis of the problem of flow around fixed objects.

The determination of the stresses in a pipeline suspended in a moving fluid involves the prediction of the magnitudes and other characteristics of the forces which will have to be resisted. Three routes, which are mutually somewhat incompatible, are available for arriving at such predictions. These routes are experience, laboratory investigation, and theoretical analysis. The route of experience alone is too long and too costly and depends too greatly on the individual. Laboratory investigation, by itself, is fraught with difficulties because of the hugeness of the prototypes and inherent weaknesses in the applicability of the results obtained from observations on small scale models. Proponents of classical hydrodynamics, have generally been far removed from the work-a-day aspects of the problem so that their formulae have often had little practical value. Each route has its bigoted adherents, but in order to arrive at the best solution, the engineer, as opposed to the craftsman, the technician, or the mathematician, must combine as best he may the good features of all three.

Osborne Reynolds in the 1880's made the earliest modern contribution toward a scientific approach to predicting the forces involved in the flow of liquids around and past rigid objects. His discovery of the importance of the dimensionless relationship or "number" which bears his name to the characteristics of flow to be expected under given conditions, gave to the science of hydraulics one of its most valuable present day tools for the solution of problems involving turbulent flow. This relationship, is $R = \frac{LV\rho}{\mu}$ in which

R = Reynolds' number (dimensionless)

L = Length parameter (diameter in ft in the case of submerged pipelines)

ρ = density of fluid (slugs per cu ft)

V = velocity (ft per sec)

μ = absolute viscosity (lb per sec per sq ft)

All formulae dealing with the flow of fluid around pipes contain constants based on experience and experiment but the utilization of Reynolds' number makes possible a wider application of empirical data and a clearer understanding of the action of the fluid.

Any fluid will flow with stream line motion under certain limiting conditions, which conditions depend largely upon the magnitude of the Reynolds' number. Above a certain value of Reynolds' number the flow becomes turbulent. When a fluid flows with turbulent motion its particles occupy successively various transverse positions without any regularity and their paths are neither parallel nor fixed.

In attacking the problem of prediction of the forces which will act on a pipeline suspended in a fluid, we are interested from a practical standpoint only in knowing what happens under turbulent flow conditions since the velocity at low Reynolds' numbers would be so small that the forces involved would be insignificant.

Drag. The component of the force on a body that results from the motion of a fluid around and past it parallel to the path of the flow is called "drag." As a fluid flows around and past a cylinder placed athwart its direction of flow, it does not maintain contact with the surface of the cylinder on the downstream side but separates. From the point of separation, the conditions are very turbulent and pronounced eddies are formed. The eddy system is known as the "wake," and the pressure within it is considerably less than the static pressure in the undisturbed fluid. The major portion of the resistance or drag is due to the decreased pressure in the wake. The drag exerted on either a sphere or a cylinder is given by the equation, $F = C_d A \rho \frac{V^2}{2}$ where F is the force in pounds, C_d is the coefficient of drag, A is the projection of the cross sectional area in square feet normal to the direction of the average velocity, ρ is the density of the fluid in slugs per cubic feet, and V is the velocity of the fluid in feet per second. The constant C_d has been found to vary in accordance with Reynolds' number. Experiments with cylinders made by Weiselberger provide the graphs shown in Fig. 1 which relate the drag coefficient to Reynolds' numbers throughout a wide range of values for both rough and smooth pipes. It is apparent from the figure that at the magnitude of Reynolds' numbers usually encountered in pipeline crossing design C_d is about 2½ times as large for rough as for smooth pipes. The degree of roughness of the surfaces investigated are not specific but it is undoubtedly true that the greater roughness factor would result in a larger drag coefficient.

USE OF THE DRAG FORMULA

In order to demonstrate the use of the drag formula let us take, for example, a 30-in. pipe coated with 3 in. of concrete suspended in water flowing with an average velocity of 6 ft per sec at 75 F. Reynolds' number will be $R_1 = \frac{3. \times 1.935 \times 6}{.00001918} = 1{,}820{,}000$. From the graph in Fig. 1, C_d (for a rough surfaced cylinder at that Reynolds' number) is approximately 0.85.

$$F \text{ (linear ft)} = 0.85 \times 3.0 \times \frac{36}{2} \times 1.935 = 88 \text{ lb.}$$

By substituting in the same formula the drag load per linear ft for a 30-in. smooth pipe suspended in a 100 mph wind is found to be approximately 25 lb per linear ft.

The horizontal wind load effects on pipeline bridges are resisted by the wind cables. On submarine lines, it is desirable to avoid such loading either by adequate entrenchment or, in some instances where small lines are involved, the provision of weight sufficient to hold the line in position on the bottom and minimize exposure. The most critical condition of drag force loading on submerged lines usually occurs during the laying or pulling operation. The possible magnitude of the drag load makes it imperative that the working season for construction of submerged lines be selected carefully so that the velocity during construction will be as low as possible and that the length of line which is unavoidably exposed to action of the current during the placing operation shall be provided with adequate supports.

WHAT CAUSES PIPELINE FLUTTER?

Vibratory or flutter loading. The periodically induced loads resulting from flow of fluid around and past a cylindrical object result in one of the most commonly observed, as well as one of the most dangerous load conditions to which suspended pipelines are subject.

The oscillating character of the circulation about a cylinder is caused by the formation of vortices in its wake. These vortices, at certain Reynolds' numbers, form and then break away on alternate sides of the cylinder's wake. The characteristic wake developed by vortices spaced regularly and alternately behind the cylinder is called the "von Karman Vortex Trail."

For flow around a rigid cylinder, the period of vortex formation and shedding, and thus the period of force reversals, is a function of the velocity of the flow. If the cylinder is free to vibrate, the proportionality between stream velocity and vortex shedding is obscured by a tend-

Suspended free end of broken pipeline across Mississippi River

ency toward the development of vortices in phase with the natural frequency of the cylinder and its supporting structure. The most severe vibration and oscillation occurs under this combination of forced vibrations resulting from vortex formation and "self-excited" vibration at the natural period of the suspended cylinder.

Examples of the deflection and stress conditions that may be expected as the result of such loading is afforded by the observed oscillation of pipeline suspension bridges, the "singing" of telegraph wires, and the "flutter" of pipes suspended in water.

Remedial action for the prevention of destructive oscillations include such measures as increasing the stiffness of the structure and thus changing its natural period; the installation of damping devices; and alteration of the structure profile by the installation of shrouds or similar devices. In the case of underwater pipelines, the best solution consists of the provision of adequate entrenchment into the bed and banks with the hope that critical conditions can be avoided during laying.

Although almost all of the reported failures of underwater pipelines have been preceded by very noticeable vibrations, very few data are available on the periodicity and the distance of travel of the pipe while it is vibrating. No known data have been obtained on the forces involved. One of the few instances of recorded vibration known to the writer was observed during the repair, at a relatively high stage, of a 24-in. pipeline crossing of the Mississippi River. The river was about 60 ft deep at the time and the average current velocity was 6 ft per sec. The free portion of the pipe was being supported in the form of a smooth curve from the bottom to the surface by cable slings of varying lengths suspended from several barges. At the time of the observed flutter the free end of the pipe with the end above the water surface was suspended from Barge No. 3 which was 220 ft away from Barge No. 2. Flutter began immediately after the pipe was free and continued at practically a uniform rate until the pipe broke several hours later near the suspension point at Barge No. 2. The noted characteristics of the flutter were that the end of the pipe moved back and forth for a distance of 18 in. and the period of vibration was 2 seconds. Fig. 2 shows the suspended free end the pipe upon which the measurements were made.

The vibrations of steel stacks due to wind are the subject of two interesting papers in the 1956 Transactions of the American Society of Civil Engineers.[7,8] These papers present and discuss new information and the theoretical background of a phenomenon which is becoming more and more important. Both the data presented and the theoretical discussion are of great interest to the designers of either aerial or underwater pipeline crossings.

Turbulence loading: Loads resulting from turbulent velocity fluctuations are irregular, and are generally obscured by the previously discussed more readily analyzed loads. These load velocity variations result in local pressure differentials of considerable magnitude and varying duration.

Pressure variations due to this phenomenon have been accurately measured by the U. S. Waterways Experiment Station by means of pressure cells in articulated concrete mat revetments in the Mississippi River and these pressure variations have been found sufficient to cause lifting and waving of that type of revetment. The pressure measurements were made at a medium stage of the river when turbulence values and pressure fluctuations were relatively low. The fact that these pressure variations were found to be correlative with velocity fluctuations, however, permits the use of more easily obtained velocity fluctuation measurements to estimate the more severe pressure differentials to which a point in a turbulent stream will be subject at higher river stages. Conformance of the occurrence of velocity fluctuations in turbulent flow with the statistical "normal error" distribution permits the reasonable extension of these data to conditions more severe than those actually measured. The results of the computations of pressure differentials at a point in the river, which, on the basis of the data cited above might be expected to occur rather frequently, are summarized in Table 1.

TABLE 1. Momentary pressure differences resulting from assumed mean velocities and velocity deviations.

Temporal Mean Velocity (ft per sec)	Velocity Fluctuation (ft per sec)	Pressure Differentials (lb per sq ft)
4	2	19.4
4	3	32.0
4	4	46.6
6	3	43.7
6	4.5	72.0
6	6	105.0
8	4	77.5
8	6	128
8	8	186
10	5	121
10	7.5	200
10	10	291

These data can only serve as indications of the forces to which a pipeline suspended in a fluid is subject on account of the velocity fluctuations. No data are available as to the extent of the area of the pipe which would be affected by these instantaneous values. The engineer will have to await a more thorough definition of the forces of turbulence before this loading can be properly designed for.

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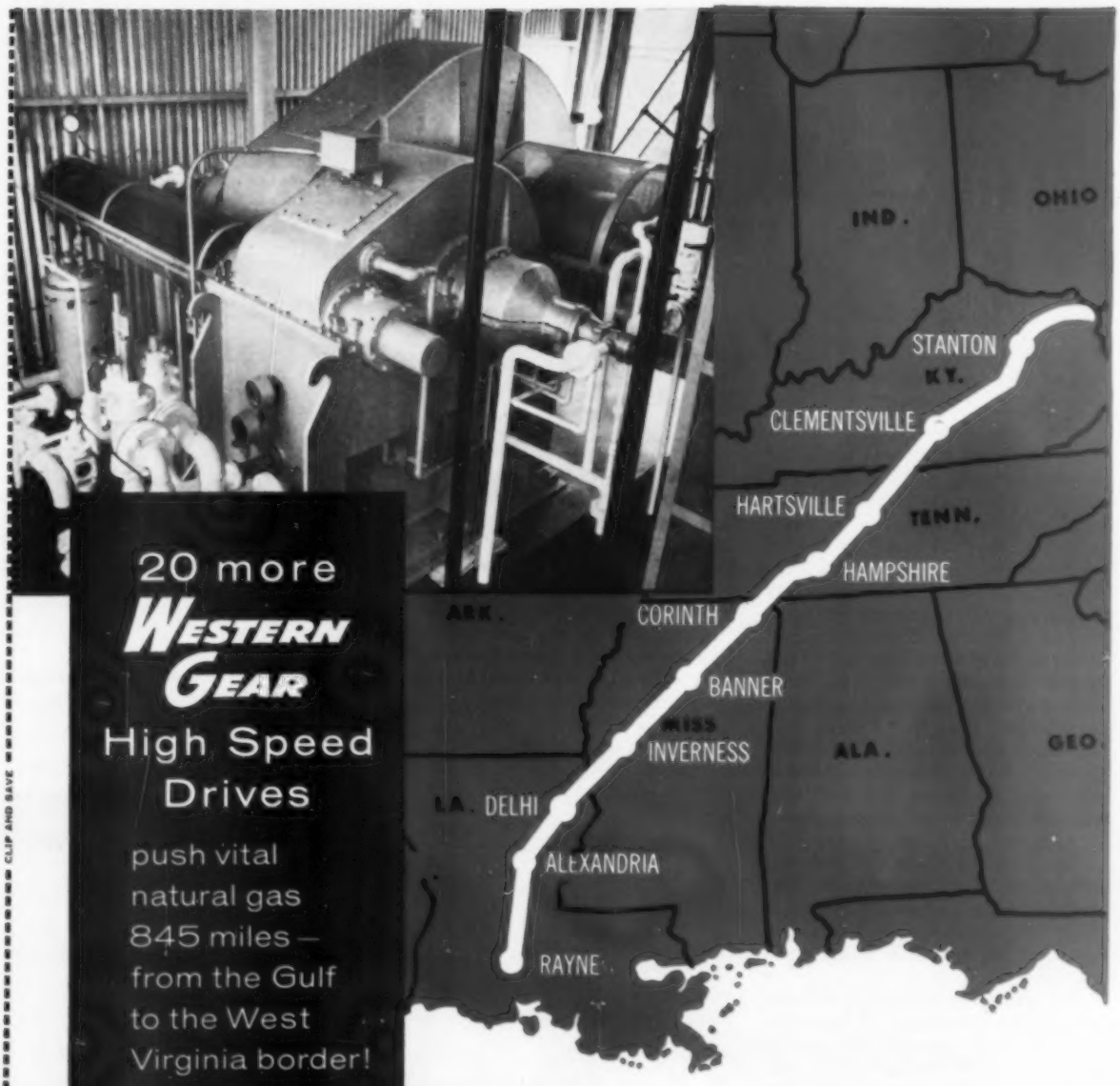

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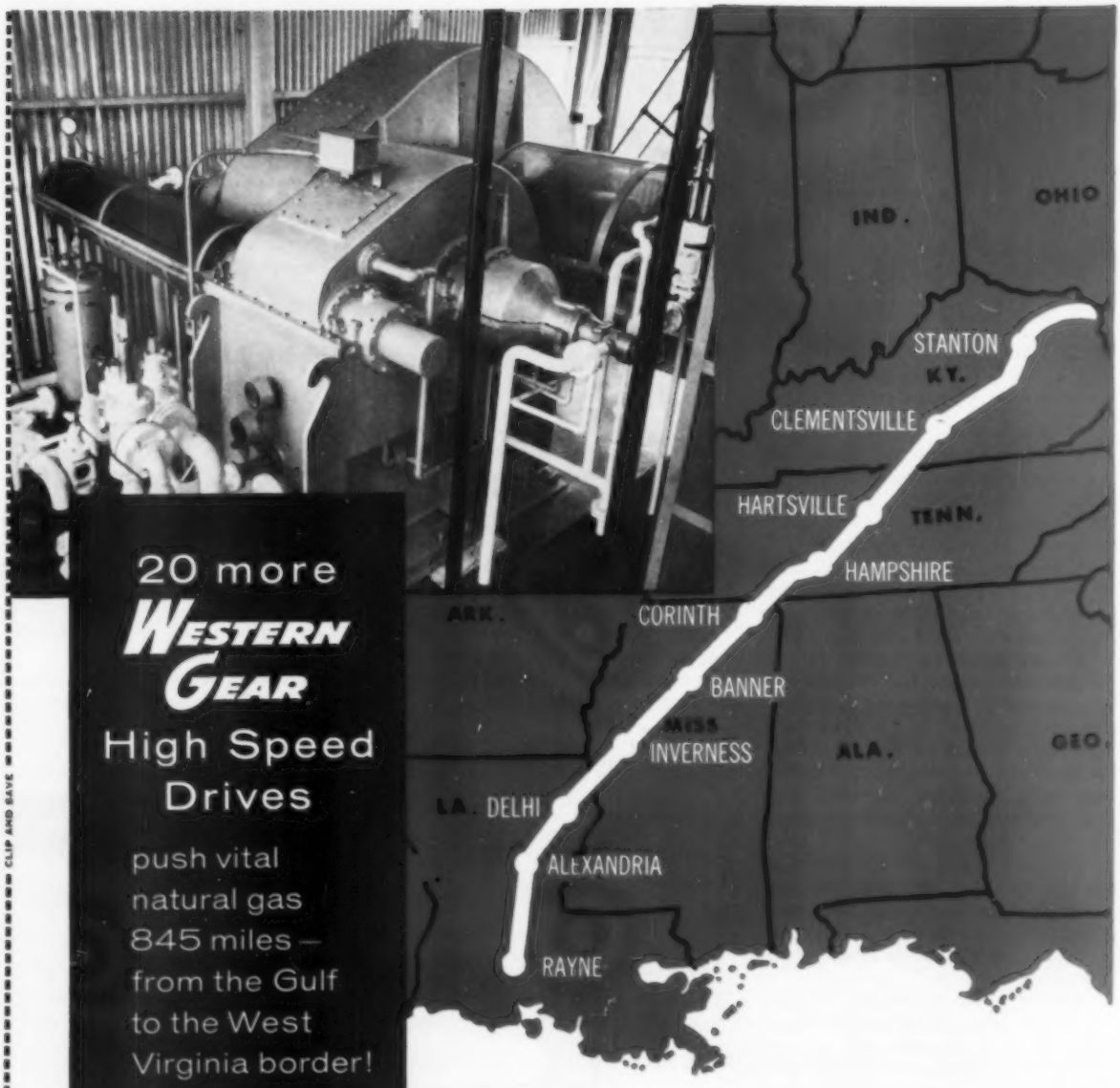

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CLIP AND SAVE

Know what fuel your diesel engine will use and ask for it

Contractors Can Cut Costs With Heavier Fuels

R. G. Johnson
Fuels Consultant, Caterpillar Tractor Company, Peoria, Illinois

WITH construction costs rising and bids becoming more competitive, how many contractors would throw away $49 a week for a single unused, unappreciated luxury? Most of them are.

This extravagance is dribbled away in the 2 cents per gal most contractors are paying for the premium fuels burned in their diesel engines, a premium paid for but not received. As will be seen later, only a few of the diesel engines used in tractors and earthmoving machines need No. 1 diesel fuel. The others operate no more efficiently, develop less horsepower per fuel dollar, and enjoy no longer life than they would burning the less expensive, heavier fuels now available.

The figure of $49 a week is arbitrary. Savings will vary, depending on how much equipment is being used on a project. But a typical spread on a medium-sized job can easily realize these savings every week.

The cost of No. 1 diesel oil, the most commonly used, and that of No. 2 furnace oil, which actually will produce more horsepower hours per gallon, vary greatly across the country. But their differential remains about the same — 2 cents less per gal for No. 2 furnace oil than for No. 1 diesel oil. Additional savings, up to another 2 cents per gal, can be realized by buying fuel in larger quantities.

If such savings are possible, why do so many contractors use the more expensive fuel? Largely it is a matter of not understanding the fuel requirements of their engines, of not knowing what fuels are on the market that will satisfy their needs, and of their suppliers not knowing which fuels they normally handle will do the job best and at the least expense.

Know What Can Be Used

The fuel requirements for an engine can be obtained from the manufacturer's specification sheets. Learning what fuels are available that will meet those requirements can most easily be handled by showing these specifications to the local supplier, who can then match what he has available to the requirements.

No. 2 furnace oil is usually available in most sections of the country. It is widely used in homes and industry for heating, cooking, and power. This being the case, the question arises, why is it not used in the engines of tractors and earthmoving machines?

Usually when a supply of diesel fuel is ordered, No. 1 diesel fuel is provided. And this is better than the engines need. The cetane number is substantially higher than required. The distillation end point is lower than necessary for good operation. And the other specifications, such as gravity, viscosity, pour point, carbon residue, and corrosion, are lower than necessary.

The diesel became so well accepted because of its inherent efficiency, 35

Diesel Engine Manufacturer's Fuel Specifications

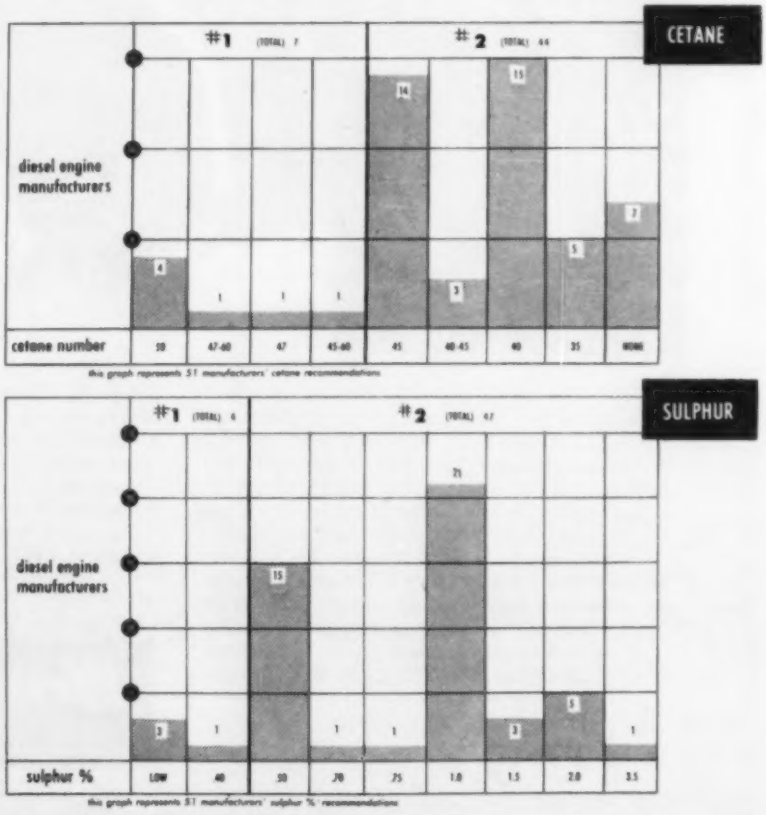

FIG. 1. Diesel engine manufacturers' fuel specifications — cetane number and sulfur content.

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percent compared with 26 percent for a gasoline engine, and because it burned an inexpensive fuel. However, now the cost differential between gasoline and diesel fuel is becoming quite narrow.

For clarification, the fuels with which we are concerned are for use in high speed diesels. For want of a better definition, anything over 1000 rpm will be considered high speed. This seems the common practice. Usually the slower speed engines can burn heavier fuels.

Table 1 gives a resume of ASTM ratings (based upon manufacturers fuel specifications). The two left hand columns prepared by ASTM contain a list of factors that are intended to serve as guideposts for typing or classifying No. 1 or No. 2 diesel fuels. The remaining columns are typical diesel fuels now marketed.

The importance of this table is the relationship that exists between the ASTM fuel specifications (columns one and two) and the fuels currently available (columns five and six). The cetane rating of the current fuels have been sharply upgraded. For instance, the cetane for No. 1 diesel fuel is approximately 50 percent and for No. 2 diesel fuel, about 25 percent higher than corresponding ASTM recommendations.

It also presents a peculiar situation where the current No. 2 diesel fuel exceeds specified volatility for ASTM rated No. 1 diesel fuel. Economically or performancewise this practice is not necessary for meeting the requirements of most diesel engines.

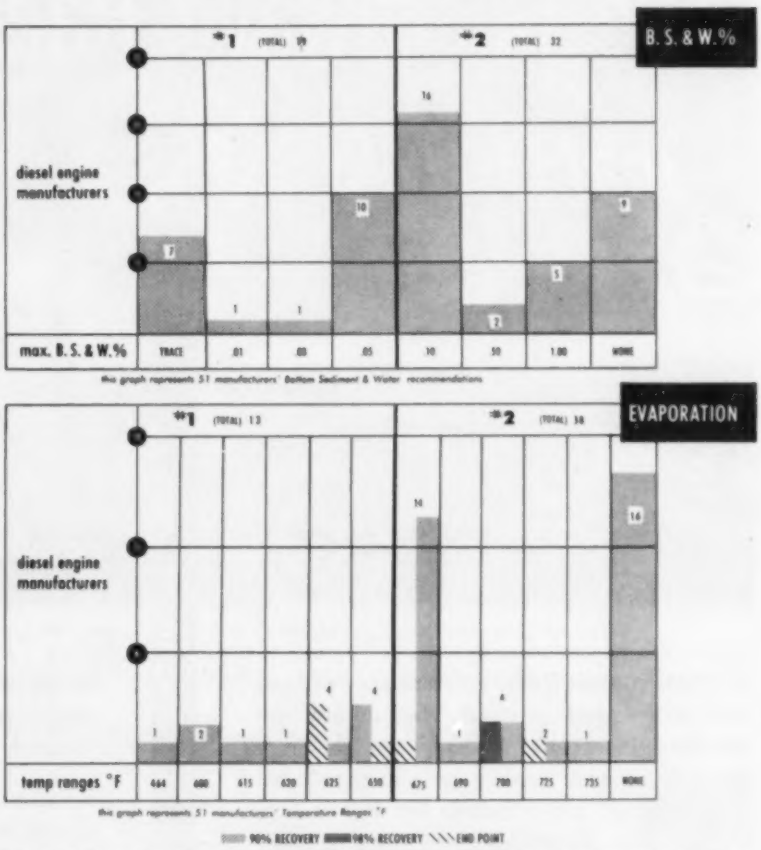


FIG. 2. Fuel specifications. Maximum BS&W permitted. Distillation or evaporation range.

Here are the Fuel Tests

The following is a short discussion of these important fuel tests:

Cetane: This component is a measure of the ignition quality of a fuel. Usually for colder climes a higher cetane rating is desirable. Cetane only helps starting — it does not provide more horsepower.

Sulfur: This component will burn as readily as the other fuel properties such as carbon or hydrogen. In so doing, however, it forms sulfur dioxide, trioxide, or both, which may form corrosive products. For this reason a limit of 1 percent maximum is usually set. Since the advent of high detergent oils, of the series II or III type, sulfur content is not as critical as formerly.

Gravity: This measurement is an index of the weight of a measured volume of fuel. Lower API ratings indicate heavier fuels, which contain more heat value per gallon, producing more work per gallon of fuel.

Viscosity: This factor is a time measure of resistance of a fuel to flow. Some low viscosity fuels do not possess good lubrication; a viscosity that is too high makes for poor fuel atomization, thereby decreasing combustion efficiency. High speed and medium speed diesel fuels usually are in a range of 33-45 Saybolt seconds at 100 F, or 2.1-5.8 centistrokes.

Pour point: This denotes the lowest temperature at which fuel will flow or pour. Usually the pour point should be 10 points lower than the operating temperature. However the pour point in itself does not limit use of a fuel in temperatures lower than the pour point, if heat can be applied.

BS&W, or water and sediment: This denotes the cleanliness of the fuel. No more than a trace should be present.

In practically all cases the refineries put out a product that is clean. Most of the water and sediment that enters thereafter is caused by improper handling.

TABLE 1—Comparison of ASTM Diesel-Fuel Specifications to Typical Diesel Fuels Currently Marketed

	ASTM-D975-53T diesel fuel spec.		Kerosine (often used as No. 1 diesel fuel	Typical fuel specifications*			
	No. 1	No. 2		No. 2 fuel oil	No. 1 diesel	No. 2 diesel	Marine diesel
Cetane number, min	40	40	60	35–45	55–60	48–50	35–40
Sulfur content, max. (%)	0.50	1.0	0.15	0.2–0.7	0.01–0.5	0.01–0.75	1.0
Gravity, A P I at 60 F	....	....	43–36	34	36–40	34–39	32
S. U. s. viscosity at 100 F	....	32–45	33	34	34–38	35	30–40
Flash point, F	100	125	115–135	150	140–170	150	150
Pour point, F	(†)	(†)	Varies	—5	0–10	0–10	0
Water and sediment, percent max.	Trace	0.10	0.10	....	0.05	0.10	0.10
Carbon residue, 10 percent bot. max.	0.15	0.35	....	0.10	0.05	Trace	0.35
Ash, percent	0.01	0.02	Nil	0.02	0.02	0.10	0.02
Copper strip-corrosion	No. 3	No. 3	....	Neg	Neg.	Pass	Pass

*These averages were compiled from information received from three of the major oil companies. †For cold-weather operation the pour point would be specified 10 F below the ambient temperature at which the engine is to be operated except where fuel-oil heating facilities are provided.

Carbon residue: This factor is a measure of how completely a fuel will burn. It indicates the amount of carbon that may be deposited within the combustion chamber. Precombustion chamber combustion systems are less sensitive to this characteristic.

Ash: This is a measure of incombustible foreign material in the fuel. Practically all of this matter is abrasive. Fuels should not have a rating of more than 0.02 ash content.

Corrosion: This is a measure of corrosive material in the fuel prior to combustion and affects the fuel pumps and injectors. Corrosion of ASTM No. 3 or less is desirable.

Fuel Specifications

The accompanying charts represent a compilation of 51 diesel manufacturers' fuel specifications. Practically all manufacturers producing diesel engines for commercial purposes are represented.

An interesting graph is the one dealing with cetane needs (Fig. 1). Forty-four of the 51 manufacturers can use a diesel fuel with a cetane rating of 45 or lower. Only seven require a higher cetane fuel. This would seem to indicate that current fuels are unnecessarily high in order to meet the requirements of the minority.

Another fuel factor that is important to the user is the distillation or evaporation specification (Fig. 2). This determines gravity of the fuel. The broader distillation range indicates a lower gravity fuel with high heat content per gallon, or, in other words, how much horsepower is contained in a specific gallon of fuel. A gallon of No. 2 diesel fuel will contain from 2500 to 5000 more Btu than a gallon of No. 1 diesel fuel.

This chart portrays that 38 of the 51 manufacturers can use a fuel evaporated at 675 F or more. Only 13 need a fuel distilled off at temperatures lower than 675 F.

The example in Table 2 illustrates the advantage of using a fuel with a lower cetane, more Btu, and higher distillation range. The relationship applies to any diesel engine.

TABLE 2—Operating Costs Comparison of Distillate Fuel
5 lb fuel per hp per hr

Grade	Typical lb/gal	Hp/hr gal	Typical price gal	Gal/hr 100 hp	Cost/hr/ 100 hp	Savings/hr/100 hp (in cents) Ker. v/s	#1D v/s	#2D v/s
Kerosine	6.91	13.82	.18	7.24	$1.30	—	—	—
#1 Diesel Fuel	6.95	13.90	.16	7.19	$1.15	15	—	—
#2 Diesel Fuel	6.99	13.98	.15	7.15	$1.07	23	8	—
#2 Furnace Oil	7.11	14.25	.14	7.03	$0.98	32	17	9

EXAMPLE: Engine — 210 hp = 1800rpm
.5 lb fuel x 210 = 105.0 lb fuel
Use #1 diesel fuel — 105 ÷ 6.95 = 15.10 gal/hr
Operating 8 hr/day = 8 x 15.10 = 122.80 gal/8 hr
#1 diesel fuel cost/gal — 16 x 122 = $19.33/8 hr
Use #2 furnace oil — .5 lb fuel x 210 = 105.0 lb fuel
105 ÷ 7.11 = 14.76 gal/hr
Operating 8 hr/day = 8 x 14.76 = 118.08 gal/8 hr
#2 furnace oil — cost/gal 14 x 118.08 = $16.53/8 hr
Savings/8 hr $19.33 #1 diesel fuel
16.53 #2 furnace oil
$ 2.80 saving per 8 hr
Operating 2400 hr/year, the saving would be:
2400 ÷ 8 x 2.80 = $840.00

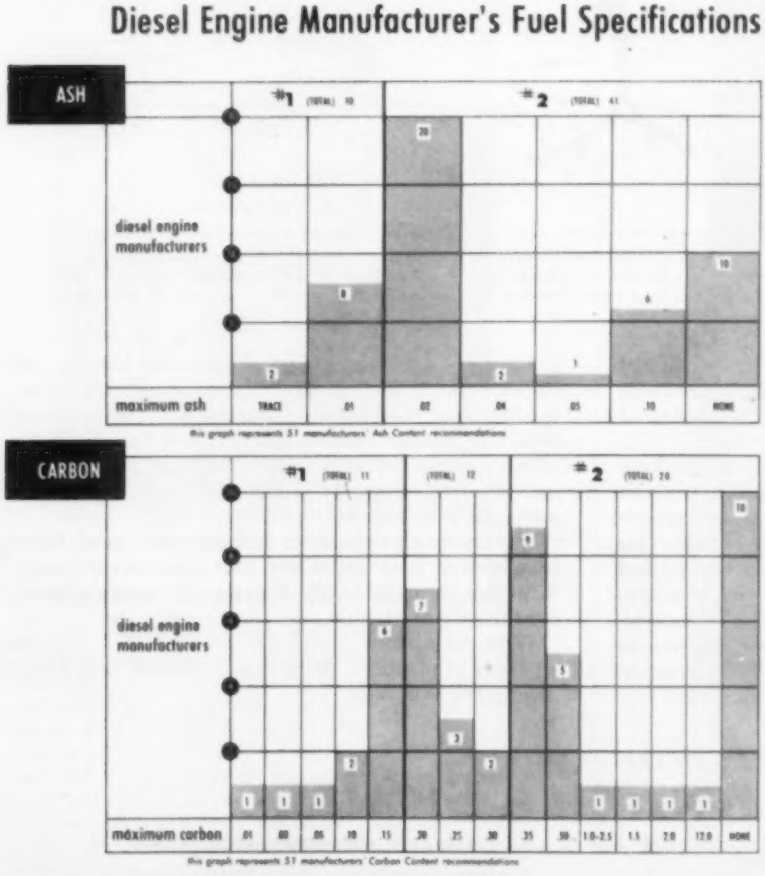


FIG. 3. Fuel specifications. Maximum ash and carbon content permitted.

It is definitely advantageous to the consumer to order as heavy a fuel as his diesel engine and temperature conditions permit. Fuel costs can represent approximately 80 percent of total operating costs for a diesel engine stationary installation. For dieselized tractors, etc., this percentage will be less because other factors are included in operating costs. This factor adds no little incentive as a method of reducing costs. It is just good economics to look closely at the largest cost first.

The remaining graphs depict several other fuel limits as specified by the same 51 manufacturers. These factors influence to some extent the degree of maintenance that may be expected if the restrictions are not heeded.

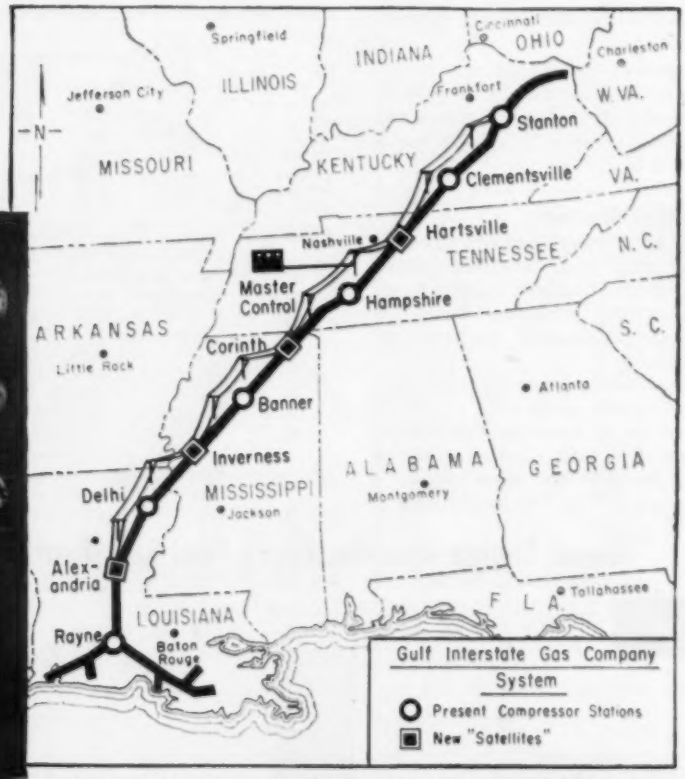
It is apparent that heavier and reduced cetane fuels are advantageous. They do a better job, and they do it at lower cost. The question is, how do you acquire them?

Like everyone else, the supplier will stock what he has a market for. He already has a market for these heavier fuels as furnace oil. The storage and marketing facilities are already established. So all the contractor need do to realize these savings, to help ease the cost squeeze he, like others, is facing, is to request these heavier fuels be supplied when he purchases fuel for his machines. ★ ★ ★

PIPELINE AUTOMATION PAYS!

Gulf Interstate's unattended "satellite" station shows how UNION C.T.C. lowers costs with safety and reliability.

UNION Control Panel at Stanton, Ky.



Construction is under way on four new engine-driven centrifugal compressor stations. All will be remotely controlled unattended "satellites." Operations will be directed from a UNION master control panel near the center of the system.

The Gulf Interstate Gas Company's "satellite" station at Stanton, Kentucky provides most economical and safe operation, according to Mr. R. Lo Chiano, assistant chief engineer at Gulf Interstate.

The Stanton station is remotely controlled from Clementsville, Ky., 90 miles away, through a UNION Centralized Transport Control System and has been on completely *unattended* operation since June 1956. This system is unique because it provides remote control and indications for a turbocharged engine driving a centrifugal gas compressor . . . the first installation of its kind. Large savings result because the operator at the master station can change the set point on the discharge pressure controller and start and stop the engine at Stanton.

Another important saving is obtained because the UNION C.T.C. System uses only one leased line circuit to transmit all the controls, indications and telemetering data. The control system used permits the use of the lowest-cost circuit. This installation was "custom engineered" using standard UNION components to meet the particular requirements.

The unattended station is definitely successful. There have been no false shut-downs that were not man made. With this in mind, future stations are being patterned after the one at Stanton.

Write for further information on UNION C.T.C. for all types of pipelines, gathering systems or tank farms. Ask for Bulletin 1052.

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Gas-Lift Water Well at Compressor Station

In remote field compressor stations where there's no source of electric power, it is sometimes practical to lift make-up cooling water with natural gas or air. Where gas is used, here is a good installation that removes most of the gas from the water before it goes into storage. Motive gas is piped down the hole through the annulus between the tubing and casing. The tubing admits gas through slots 20 ft or so above the water sand. The water flows up the tubing into a separator made of 12-in. pipe as shown. Here the gas disengages from the water, which flows out the bottom of the pipe onto the station sump. Note the ladder built onto the riser which permits inspection of the separator.

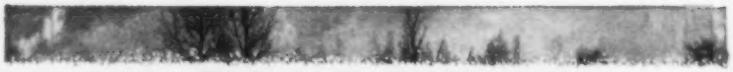
Rubber Cement Can Be Used For Thread Compound

When leaks in screw piping persisted, one company resorted to rubber cement as a thread compound. The new station had just gone into operation, and the screwed piping sprang hot oil leaks, etc. Even after the piping was dismantled and made up tighter, some of the leaks persisted. In the press of operations, the maintenance crew was ordered to stop the leaks at all costs, and the solution was found when one of the men suggested that rubber cement — the kind used to stick sponge rubber seals to metal doors — be used in place of thread compound.

Jeep Rescued From Junk Heap Makes Mobile Pumping Unit

A 108 years from now, when the popular mode of transportation will be atomic-powered helicopters or something, someone will still be finding new uses for jeeps — the real heroes of World War II. For old jeeps never die — and they seldom fade away either.

Here's one that probably saw more campaigns than six generals, yet it is still at work. A contractor removed its driveshaft, seat, and a few other things and made a portable pumping unit for utility work. The centrifugal pump is mounted so it can be driven by the venerable jeep engine, and a trailer hitch was clamped to the front wheels so the unit can be hauled along the right-of-way.



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In the frozen north... Canada's first "BIG INCH"

WESTCOAST TRANSMISSION COMPANY is laying a 30 inch pipeline to tap the prolific gas resources of British Columbia and Alberta. This line runs from these fields due south to the international border. The 688-mile main line marks the first large-scale interchange of natural gas between western Canada's new and expanding fields and U. S. markets. A .O. Smith's Milwaukee mill supplied approximately 22% of the 30-in. pipe used on the project.

Northwest passage... new mileage for world's longest "crude line"

INTERPROVINCIAL PIPE LINE COMPANY has 1774 miles of main line now in service. They are extending this system another 156 miles during 1957. This big crude oil carrier extends from Edmonton, Alberta, to refineries in the Prairie Provinces and Ontario, in Minnesota, Wisconsin, and Michigan. Over 70% of the original line to Superior, Wisconsin, was supplied by A. O. Smith as well as most of the pipe for current and subsequent looping projects.

Want more facts about A. O. Smith products for the petroleum industry? Write today for free, illustrated brochure, "OIL"

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Just about 30 years ago, A. O. Smith researchers developed the first truly practical method of mass-producing line pipe. *Result:* Pipelines, as we know them today, became economically feasible.

And A. O. Smith has kept the pace — with painstaking attention to quality in every production phase. This is the reason why A. O. Smith pipe, made and installed as far back as 1928, is still in operation today. This is the reason why you'll find A. O. Smith pipe in so many major high-pressure lines (including the four current projects pictured and described on these pages).

In the arid southwest... a river is pushed aside

To cross New Mexico's San Juan river, **EL PASO NATURAL GAS COMPANY** temporarily diverted the river . . . used dry-land pipelining methods. The new line will supply an additional 350,000,000 cubic feet daily to customers in California and 100,000,000 cubic feet more daily to customers in Arizona, New Mexico, Texas and Nevada. A. O. Smith Corporation of Texas mill supplied approximately 224 miles of 34-in. pipe for the project.

Underwater project... "MUSKRAT LINE" submarines toward completion

TENNESSEE GAS TRANSMISSION COMPANY'S 355-mile pipeline extension is laid underwater four-fifths of its length — traversing swamps and marshland. It will give the Tennessee gas system more than 9500 miles of line in 15 states, with average daily capacity of 1,800,000,000 cu. ft. A. O. Smith supplied the 18 and 20-inch pipe and a portion of the 24-in. pipe for the new extension.

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16-years' research gives Standard-Vacuum answer to problem of

Pipelining Congealed Oil In Sumatra

***Based on report by:* J. M. Rupert**
and
B. N. van Diemen de Jel
Standard-Vacuum Petroleum Maatschappij

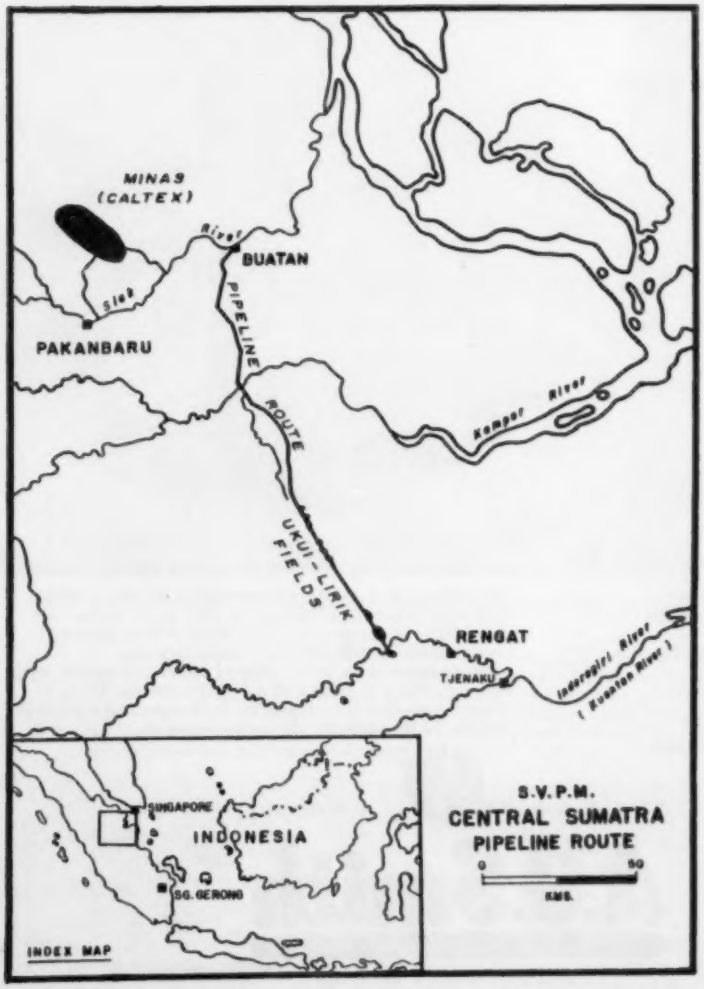
A unique crude oil pipeline is being laid across the equator in Central Sumatra's jungle by Standard-Vacuum Oil Company. Unusualness of the line, believed to be unparalleled in the petroleum industry, stems from the kind of crude oil it must transport. Having a gravity of 34-deg API and a pourpoint between 105 and 110 F, its viscosity varies widely at different temperatures. A liquid in the direct rays of the sun, it will freeze sufficiently during the coolest part of the night to support the weight of an average man.

One of the key factors in making the oil move under these circumstances is a 3-in. hot-water "defroster" line, laid beneath but in contact with the crude line.

This unusual pipeline is a part of a four-year, $80,000,000 program that will result in a 20,000 bbl per day increase in the company's Indonesian production by early 1958. Other parts of the program include development of the Lirik field, modernization and enlargement of the refinery at Sungei Gerong. The refinery is on the Musi River near Palembang in South Sumatra, about 475 miles from the pipeline terminus.

The 90-mile, 8-in. pipeline extends from the Lirik field near the Indragiri (Kuantan) River to a terminal at Buatan on the Siak River. Caltex production from the nearby Minas field has been shipped by tanker down the Siak for many years.

Right-of-way traverses hilly jungle country with the exception of approximately 13 miles of swamps near small streams and rivers. In some localities the vegetation is extremely heavy and its clearing, always difficult, has been aggravated by monsoonal rains. Some of the hills are high and their slopes steep, requiring cuts and fills of 30 to 40 ft.



Route of pipeline being built across Sumatra's steaming jungle from Lirik field to Buatan Terminal.

Years of Research

It has taken years of patient research and experiment—interrupted by a war — to find an engineering solution to the difficult problem of flowing this crude out of the jungle.

The remarkable characteristics of the Lirik crude have fascinated — and exasperated — Stanvac engineers and technologists ever since they discovered the fields in 1939 and 1940. Here, in a steaming jungle one degree off the equator, was found a rich crude that would have been no easy matter to move even from Signal Hill to Long Beach, or between Tulsa and Sapulpa. In the view of its bewildered discoverers, the crude really belonged to the Arctic Circle.

Overnight, the crude congeals so hard that it can be cut into neat chunks with a knife in the morning — just

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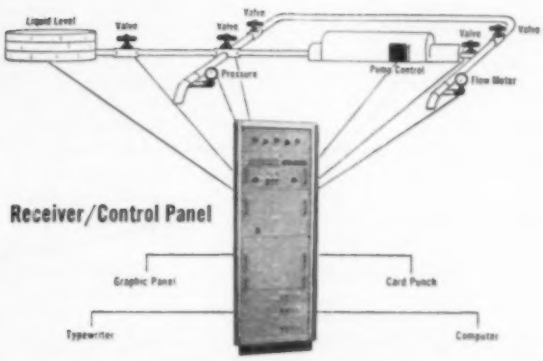

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Any number of remote pump stations or functions can be controlled from one or more control locations with these Bendix engineered systems.

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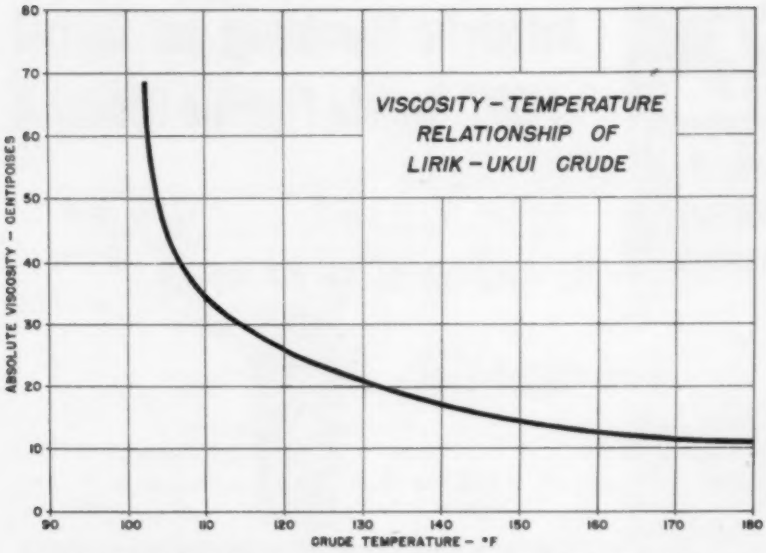


Viscosity of the crude varies greatly with temperature, as shown by this chart.

like butter. And, like butter, it becomes liquid in the direct rays of the equatorial sun.

The reservoir temperature in the Lirik field is relatively high. It amounts to 173 F at 1700 ft subsurface. This corresponds to an extra-ordinary temperature gradient of less than 20 ft per deg, as compared to a normal gradient of 60 ft per deg.

It would be tough enough to ship this crude through an accessible civilized countryside. But here it was, in the Kuantan River basin, approximately 40 miles inland from the nearest delta on Sumatra's east coast. The Lirik producing area itself, situated on low rolling hills, has a convenient topography for oilfield operations. The climate is humid — an average of 115 in. of rain yearly. Most land east of Lirik is inundated during the rainy season and is unsuited as a pipeline route to a deep-sea terminal. By going north to the Siak, the pipeline is mostly on dry terrain.

Early plans for barging the field output to a deep-water terminal along the Kuantan were complicated by river conditions for the first 24 miles.

At least six ideas were considered to coax the crude through a pipeline. A blend of 35 percent naphtha or some equivalent solvent was found in actual pumping tests to be pumpable in a buried line. But it required a larger diameter pipeline, a terminal topping plant, and a system to return the solvent to the field.

Also discarded was emulsification with water because the crude tended to form stable emulsions that could not be separated commercially.

Tests with glass tubes indicated some success for moving the crude through a line as a solid plug riding within a sleeve of water. But the idea was scrapped as not feasible.

Excessive investment ruled out ideas of an electrically heated pipeline, or installation of "vis-breaking" equipment, which would in effect amount to a cracking plant in the field to alter the crude's exceptional viscosities.

The best plan appeared to be heating the crude at various stations along the pipeline, and research concentrated on actual pumping tests as war approached.

First Tests In 1941

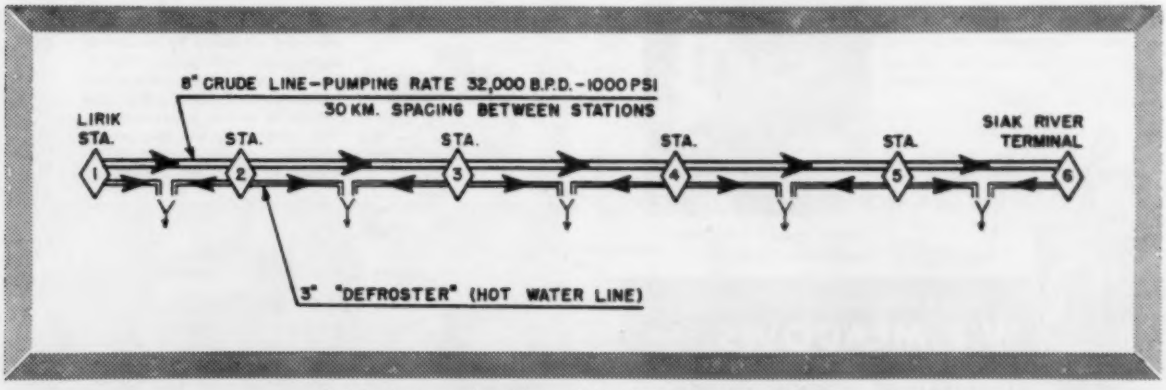
First tests began in 1941, on an experimental 6-in. pipeline 1¼ miles long at Lirik. It had a rated capacity of 9500 bbl per day with facilities to heat the crude to temperatures up to 200 F. Before the Japanese occupation, this experiment yielded useful data on buried and unburied pipeline characteristics, pressure behavior, heat loss, and other factors.

The Japanese drilled additional wells and laid a 6-in. surface pipeline 35 miles between Lirik and Sungei Tjenako, on the Kuantan River, where barges could load. A 2-in. steam line was laid parallel and wired to the crude line with an insulation of coconut husks. Heater stations served the defroster line every 2½ miles, without intermediate crude pumping stations. Sketchy information indicates the Japanese thus moved about 200,000 bbl.

In 1949 Stanvac constructed a new, 6-in., 7-mile "pipeline to nowhere," which ran 3½ miles from Lirik and back to the storage tanks there. Pressure gages and thermometers studded the line for intensive observations and a 1⅘-mile section was eventually buried from 6 to 12 in. deep with a 2-in. hot water defroster line.

From this first post-war project, Stanvac engineers acquired vital data that profoundly influenced design of the present pipeline.

During 1954 Stanvac buried a 6-in. crude line on top of a 2-in. defroster line between the Lirik producing field and Djapura, a barge loading terminal on the Kuantan River four miles distant. About 2000 bbl a day began mov-



Sketch of 8-in. crude oil line and 3-in. hot water "defroster" line.

ing through this system in 1955 for trans-shipment to the Sungei Gerong refinery at Palembang. This is the fourth project (including one built and operated by the Japanese) from which the know-how has been accumulated for the design of the pipeline now nearing completion.

Design of Present Pipeline

The pipeline now under construction was designed with the thought in mind that every possibility of operational difficulties should be considered. Therefore, pumping rates, heating, and station spacing were maintained well within a zone of safety to provide for failure of equipment, human failure, and the effects of adverse weather conditions. The system was also designed to allow for a future increase in throughput rates.

Several factors limit the design of a pipeline for Lirik crude in addition to its characteristics, which are as follows:

Crude Characteristics

Gravity API	34.0
Viscosity	See Fig. 2
Pensky Martens Flash	84 F
Vapor Pressure at 100 F	1 lb
Pourpoint	105 F to 110 F

It has been observed on occasions, when the crude has been heated above 160 F, that some light components are lost, and if excessive heat is applied, coking occurs. Therefore, 155 F has been selected as the maximum operating temperature.

Past experience has shown that while pumping Lirik crude, if the temperature falls below the pourpoint, pressure along the line drops rapidly. When pumping crude with temperatures below the pourpoint, it is possible that a shutdown could occur if soil surrounding the pipe was saturated by excessive rain, resulting in an appreciable increase in the heat transfer coefficient. Limits on operating temperatures, therefore, are from a minimum of 110 F to a maximum of 155 F.

Ground temperature in the Lirik area at 2½ ft below the surface is 83 F. Soil conductivity throughout the pipeline right-of-way is considered to be fairly constant during the dry season, but can change considerably in some localities during the wet season. Although a coefficient of heat transfer from pipe to soil is considered to be 0.8 Btu per sq ft per hr per deg temperature differential, provision had to be made for safety should the heat transfer coefficient increase.

The defroster line is not effective for the entire distance between stations, consequently hot water is pumped from each station to a point half way between them.

Hot water lines are operated only when starting up a line containing congealed crude. When the line has been heated sufficiently to allow movement of the crude the defroster is shut down. The defroster will be operated at 1000-psi discharge pressure and 180 F initial temperature. It will require from 13 to 19 hours to defrost the 8-in. line, depending upon weather conditions. Crude in the line after a short interruption in pumping does not cool enough to make defrosting necessary.

Station Equipment

There will be five pumping stations spaced 18½ miles apart and a loading terminal. Each station will be equipped with four triplex pumps driven by diesel engines through couplings. Each pump has a capacity of slightly less than 11,000 bbl per day. One unit will be used as a spare. If required, plungers in the pumps can be enlarged to increase pumping capacity.

Heat will be provided by 60-hp oilfield boilers, and there will be three crude oil heat exchangers and two water heaters. Defroster water will be pumped by double-acting duplex pumps powered by diesel engines; and by 10x4x10 steam pumps.

Diesels will use Lirik crude as fuel. When units are shut down, however, regular diesel fuel will be run through the fuel lines and fuel pumps to avoid plugging with congealed Lirik crude.

The three Buatan Terminal loading pumps will be centrifugals with diesel prime movers. Other equipment at the terminal will be the same as installed at the pump stations except for the crude oil heat exchangers.

Storage tanks will be provided with heating coils and all crude lines either steam or hot water traced. Automatic remote reading tank gages will be installed.

Boilers and pumping units will be skid-mounted, which facilitates their installation.

The communications system will be telephonic, consisting of three metallic circuits.

Automation will be used to an extent practical for the operation of the system. Meaning full automation such as unattended remote control pumping stations is not possible.

When the pipeline system is in operation the number of permanent employees will be 160 to 180. ★ ★ ★

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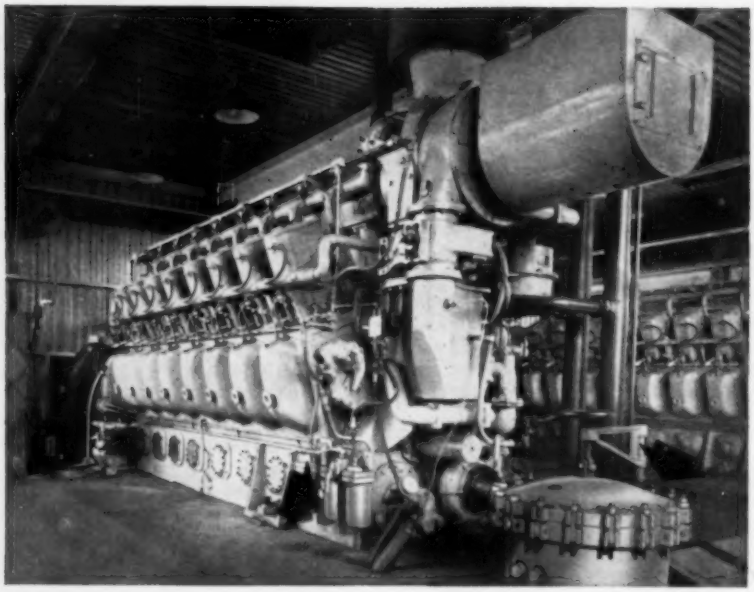

NUGENT FILTERS

. . . The best protection any engine can have

Nugent Filters protect both lube and fuel oil for the Alco 251 Diesels installed at the Laton (Kansas) Pumping Station of the Service Pipe Line Company. This recently built pipeline conveys crude oil from Fort Laramie, Wyoming, to Freeman, Missouri.

To help guard against the serious consequences of a power failure, a Nugent #1555-4L12 filter provides the Alco Diesels with full flow filtering of lube oil. The filter cleans all the engine lube oil in circulation every cycle before going to the bearing, removing particles as small as 2 or 3 microns.

Fuel oil, too, receives the protection of Nugent filtering. A #1555-BF-1R Duplex Filter is mounted on the suction side of the fuel oil pump — protection for trouble-free injection.

You can prevent harmful impurities from reaching spots where they can accelerate wear, shorten engine life or cause power stoppage by employing Nugent Filters. They offer a choice of full flow or by-pass filtering with the same unit. Recharges are inexpensive and easy to change. Simple piping makes installation no problem.

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Canadian News Notes

Trans-Canada. Good weather in early July speeded construction work on all four sections of the 34-in. natural gas pipeline of Trans-Canada west of Winnipeg, and one spread was just about doped out at the middle of the month. Universal Pipe Lines, Ltd., holding the contract for section 3, was able to get all its pipe strung last winter while the right-of-way was frozen.

The Universal spread made history for 34-in. pipe when its dope gang ran 16,400 ft on the best day, using nine pots. Pipe gang footage has averaged about 11,000 ft throughout the job, with a high day of about 13,000 ft. A feature of the pipe gang is a compressed-air internal line-up clamp, powered by a portable compressor carried on the stringer bead welding unit.

Dutton-Williams Brothers, Ltd., on section 4, is scheduled to finish early in August. Price-Poole, section 5, is expected to complete its work by early August. Canadian Bechtel, Ltd., on section 6, is due to complete pipe laying by the end of August.

Westspur. Majestic Contractors, Ltd., completed the 20-mile, 8-in. branch line for Westspur Pipe Line Company from the Glen Ewen field of southeastern Saskatchewan to the Alida terminal of Westspur in the same region, in record time. The spread kicked off on June 23 and the line was doped out on July 7 in spite of three days of down time for rain.

Westspur main line loop was doped out by the end of July. The loop consists of 75 miles of 16-in., from the Steelman field to the Cromer pumping station on the Interprovincial line in Manitoba, and will raise capacity of the Westspur system to approximately 125,000 bbl per day. Jack Engelking is spread superintendent for Engelking & James, Ltd. which has a general subcontract from Gragg (Canada) Ltd.

Trans-Mountain. The 50-mile, 24-in. loop of the Trans-Mountain Oil Pipe Line Company main line, between Bickerdike pumping station and a point six miles west of Hinton, has been completed. Dutton-Williams Brothers, Ltd. was the contractor, with Jerry Nash, formerly of Fulton-Banister Ltd., as spread superintendent. The 17 miles of muskeg ground, including one straight section of four miles, was traversed completely from riprap built up four feet above ground level.

The loop is the first stage of an expansion program designed to coincide with the completion of two new refineries on Puget Sound in 1958-59.

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Pipeline Personals

Cliff Williams has been named safety director and equipment superintendent of Somerville Construction Company. Cliff, a five-year veteran with the Somerville organization, has been pipelining for over 8 years and has gained a background of varied experience that is ideally suited to the requirements of a successful safety director.

J. C. Bauguss Jr. has been appointed valuation engineer, headquarters in Los Angeles, for Southern Pacific Pipe Lines, Inc.

Fred C. Koch, prominent Wichita oil man, has been elected a member of the board of directors of Northern Natural Gas Company. He is currently president and director of Wood River Oil and Refining Company, Rock Island Oil and Refining Company, and the Koch Oil Corporation, all of Wichita. Other directorships held by Koch include the First National Bank of Wichita, Koch Engineering Company, the Clover Oil Corporation and Vance Oil Corporation.

The directors of The Texas Pipe Line Company have approved several changes in their corporate officers. **C. E. Landon** will assume the duties of assistant to management; **W. R. Griffin Jr.** will serve as treasurer and head financial officer, and **L. J. Shelton** was elected comptroller of the company and as such will supervise the general accounting operations. Landon formerly served as treasurer; Griffin, comptroller, and Shelton, formerly secretary and treasurer of a pipeline company affiliated with The Texas Company.

R. G. Follis has been elected chairman of the board of Trans-Arabian Pipe Line Company. Follis, who is also chairman of the board of Standard Oil Company of California, succeeds **Clyde A. Swigart,** retired. At the same time the Tapline board of directors announced that **John Noble,** president of the company, would also be chief executive officer.

Richard P. Cocke was named vice president of Trans-Arabian Pipe Line. Cocke, who has served as secretary, treasurer and comptroller of Tapline since 1951, will henceforth be vice president, secretary and treasurer. He will be succeeded as comptroller by **O. T. Swanson,** who has been Tapline's assistant comptroller and assistant treasurer.

Texas Gas Transmission Corporation has elected **F. K. Rader** vice president and **H. L. Stowers** vice president and chief engineer. Rader formerly served as assistant to the executive vice president and Stowers has been chief engineer for Texas Gas and a predecessor company for the past 14 years.

F. K. Rader

H. L. Stowers

E. F. Hindman was named superintendent of the pipeline department of Texas Gas Transmission Corporation; **W. O. Davis** succeeds Hindman as manager of the company's Louisiana division, and **Edward Hamric** becomes the pipeline department's assistant superintendent. Davis and Hamric have been assistants to the pipeline superintendent. Hindman joined Texas Gas in June 1949, as general superintendent of the company's former Louisiana subsidiaries. He was named manager of the Louisiana division when it was created out of the subsidiaries in July 1955. Davis was employed by Memphis Natural Gas Company, a predecessor of Texas Gas, as chief dispatcher. Hamric joined Texas Gas in 1948 as an engineer following graduation from the University of Mississippi.

E. F. Hindman

W. O. Davis

Edward Hamric

Warren Pond has recently joined Trunkline Gas Company as Houston district landman. His headquarters will be in the company's district offices in Houston, Texas. Prior to joining Trunkline Gas, Pond worked five years for Gulf Oil Corporation in Houston and later in Midland, Texas. He has also worked as an independent oilman.

C. E. Coffey, a veteran of 23 years experience in natural gas compressor station operation with Texas Gas Transmission Corporation and a predecessor company, has been appointed superintendent of the Texas Gas compressor department's Kentucky and Indiana division. Coffey was manager of the Texas Gas compressor station at Jeffersontown since its construction was commenced in 1949.

E. N. Little, superintendent of the Houston district of Sinclair Pipe Line Company has been named assistant division manager of the Texas division with headquarters at Fort Worth. **J. R. Ligon** has been named assistant chief general engineer at Independence, Kansas. Ligon will remain on temporary assignment at the division headquarters in Fort Worth. Other appointments include: **R. J. Eubank** named acting district superintendent of the Houston district. Eubank was formerly assistant district superintendent of the district. **J. B. Gossett** named assistant district superintendent of the Houston district, with headquarters at Silsbee. **H. V. Watkins** to assistant district superintendent of the Wichita Falls district. **E. I. Leabo** has been named assistant chief engineer and **R. H. Meyer** named project engineer at Independence.

Vern Horte, former petroleum engineer with the consulting firm of DeGolyer and MacNaughton, Dallas, Texas, has joined Trans-Canada Pipe Lines Limited in Calgary as chief gas supply engineer.

Lester T. Potter has been elected president of the Lone Star Gas Company succeeding **D. A. Hulcy,** who will remain with the company as chairman of the board.

Jensen Engineering Company has announced the appointment of **L. R. Van Arsdale** as vice president. He has been sales manager of the company for the past two years and will continue in this capacity.

Paul F. McBride has been named chief engineer for Pacific Northwest Pipeline Corporation. He was acting chief engineer for several months.

C. W. House, southern division superintendent, pipeline department, General Petroleum Corporation, has completed 35 years of continuous service. House, who was first employed by General Petroleum as a welder in 1922, has been division superintendent since 1948.

Robert O. Parker, supervisor of the accounting department at Trunkline Gas Company, Houston, Texas, has been named assistant controller.

J. M. Clark, vice president for production of the Pacific Northwest Pipeline Corporation, has resigned to devote his full attention to the production activities of Northwest Production Corporation, a Pacific Northwest subsidiary in which Clark is also a vice president. **Lester G. Truby Jr.,** Pacific's manager of production operations, is being promoted to new responsibilities as manager of production and will have charge of all phases of Pacific's production department, including geology, leasing, and drilling.

Fulton W. Copp, now manager of rates and sales for Pacific Northwest Pipeline has been elected to the position of vice president for sales. He was a vice president of Northwest Natural Gas Company for a number of years.

William G. Cutler has been appointed manager of production operations and reservoir engineering department of Pacific Northwest Pipeline. Cutler replaces Truby. Cutler has been associated with Pacific since June 1955 as a petroleum engineer.

N. E. Tanner, formerly president, was elected chairman of the board, and **Charles S. Coates,** formerly executive vice president and general manager, was elected president of Trans-Canada Pipe Lines Ltd. Tanner's heaquarters will be at Calgary, Alberta, and Coates will continue to maintain offices in Toronto. **Edmund M. Foo,** former project engineer with the Alberta Petroleum and Natural Gas Conservation Board, has joined Trans-Canada Pipe Lines in the Calgary office as gas engineer in the gas supply department.

N. E. Tanner

C. S. Coates

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Pipeline Projects

PG&E Plans $330,000,000 Line From Canada

Pacific Gas and Electric Company has announced plans to bring natural from Canada into California through a $330,000,000 pipeline system. The line would be in operation in 1960 and would have an initial capacity of 400,000,000 cu ft a day. Construction of the 1300-mile pipeline is subject to authorization of governmental agencies of Alberta and Canada, the Federal Power Commission, and the California Public Utilities Commission.

The project would connect the California market with natural gas resources in Alberta, and would augment the company's present supplies from fields in California, Texas, and New Mexico. A substantial volume of gas already has been contracted by a subsidiary of PG&E, according to Norman R. Sutherland, president.

The line would cross several mountain ranges, including the Canadian Rockies, traverse parts of British Columbia, Idaho, Washington, Oregon, and Northern California, terminating at PG&E's Antioch, California, station.

Agreements have been reached with Canadian Western Natural Gas Company, Ltd., of Calgary, and Northwestern Utilities, Ltd., of Edmonton, gas-distributing utilities in Alberta, for purchase, sales, and transmission of gas, according to Sutherland.

PG&E would be assisted in the engineering and construction of the system by Bechtel Corporation.

Four Corners to California Natural Gas Line Talked

Trans-Western Pipe Line Company has been formed to build a gas line from the Four Corners area to a point on the California border not yet disclosed. Involved are Warren Petroleum Corporation, Monterey Oil Company, and J. B. Butler, Houston consultant.

John McMillan, Monterey executive vice president, is president of Trans-Western.

Heretofore, oil companies have avoided entering the gas transmission field because of utility type regulation by the Federal Power Commission. In this instance, however, it is said that Trans-Western is considering an industrial consumer as the sole customer, which it could serve directly rather than through utility firms. By so doing, FPC likely would enter the picture only in connection with transportation charges and not in regard to field price of the gas.

Mississippi River Fuel Proposes Construction

An application by Mississippi River Fuel Corporation, of St. Louis, Missouri, proposing the construction of pipeline facilities estimated to cost $6,936,600 and designed to increase the company's natural gas system sales capacity by 10,000,000 cu ft per day, has been accepted for filing by the Federal Power Commission.

Mississippi seeks authority to build 6400 additional hp in existing compressor stations and 54 miles of 26-in. pipeline paralleling sections of its existing system.

Muskegon Pipeline Project Gets Underway

Pipe for the construction of the 165-mile crude oil pipeline from Griffith, Indiana, to Muskegon is underway at seven railheads in Michigan and Indiana, according to E. O. Scott, project supervisor.

The new crude oil pipeline is being constructed by the Service Pipe Line Company, as construction and operating agent for the Muskegon Pipe Line Corporation, which has been organized by Aurora Gasoline Company and Service Pipe Line Company.

Unloading points are Covert, Grand Junction, Fennville, and McCool in Michigan, and Michigan City, Chesterton, Lottaville, and Hobart in Indiana.

To be 10-in. in diameter and with an initial capacity of about 26,000 bbl a day, the new line is being constructed to supply western Michigan refineries. Two at Muskegon, the Aurora Gasoline Company and the Naph-Sol Refining Company, will receive oil produced in the southwestern and Rocky Mountain areas.

Construction of the line was scheduled to get underway early in August. By late 1957 it should be in operation.

Three ground survey crews of the Southern Mapping Company, Greensboro, North Carolina, are working on the survey. One crew was working north from Griffith, one south from Muskegon, and one in the St. Joseph-Benton Harbor area.

Service has opened construction offices at 519 Main Street in St. Joseph, Michigan.

Nasser and Onassis Plan Suez-Port Said Pipeline

Important news coming out of Egypt says President Nasser and Aristotle Socrates Onassis have entered into an agreement for construction of a Suez to Port Said pipeline. The line, of 32 to 26-in. diam pipe, would have a capacity of 500,000 bbl a day and cost $37,000,000 to build.

Supertankers too large to use the Suez Canal would load oil in the Persian Gulf and discharge it into the pipeline at Suez. The oil would be reloaded onto tankers at Port Said, 102 miles away.

Onassis is interested primarily because he could use his fleet of supertankers, which must now go around the Cape of Good Hope.

The plan provides for establishment of an Egyptian joint stock company having a 12-year concession to construct and operate the line. Egyptians would own 60 percent of the stock and foreigners 40 percent, the latter chiefly Onassis.

At the end of this concession period, Egypt would assume full operation of the pipeline. During the 12-year period, however, the Egyptian government would receive as royalty 50 percent of the collected charges.

Fast Job Being Done in Reconverting Little Inch

When the Federal Power Commission gave authority for reconversion of the Little Big Inch pipeline on June 21, Texas Eastern Transmission Company had its crews in readiness to begin work immediately. As a consequence, this system, which has been carrying gas, will be ready to transport petroleum products about mid-August, announces Orville S. Carpenter, president.

At the same time, Millard K. Neptune, executive vice president of Texas Eastern, in charge of Little Big Inch operations, announced that construction would begin on a 14-in. line from Seymour, Indiana, to Chicago about August 1 and will be placed in service in September.

Construction of substitute gas facilities has progressed to the point that physical separation of the Little Big Inch from the gas system will occur during August, and about the same time the company will begin receiving products into its tanks in preparation for initial pumping in September, he said.

A $30,000,000 Program Of Construction Approved

Texas Eastern Transmisison Corporation and its wholly-owned subsidiary Texas Eastern Penn-Jersey Transmission Corporation have received Federal Power Commission authorization for expansion projects that will add approximately 110,000,000 cu ft to the daily capacity of Texas Eastern's natural gas transmission system.

Total cost of the project for both companies will be approximately $30,300,000, with the parent company's facilities costing some $25,900,000 and Penn-Jersey facilities about $4,400,000, according to Orville S. Carpenter, president of Texas Eastern.

The facilities authorzied will add 67,610 hp of compression facilities and 137 miles of pipeline to Texas Eastern's system.

Included in the facilities authorized are a new 10,250-hp compressor station to be built near Mont Belvieu, Texas, on the company's recently authorized 30-in. Vidor-McAllen pipeline. The company will add horsepower on its existing 30-in. line between Beaumont, Texas, and Kosciusko, Mississippi, as follows: 5200 hp at Gillis station, Beauregard Parish, Louisiana; 5280 hp at Opelousas station, St. Landry Parish, Louisiana; 5200 hp at St. Francisville station, West Feliciana Parish, Louisiana; 5280 hp at Union Church station, Jefferson County, Mississippi; 5200 hp at Clinton station, Hinds County, Mississippi, and 5000 hp at Kosciusko station, Attala County, Mississippi.

Texas Eastern also received authority to add approximately 2200 hp to a previously authorized station near Linden, New Jersey.

Texas Eastern also was authorized to construct approximately 96.5 miles of additional 30-in. pipeline loops along the company's existing 30-in. line between Kosciusko, Mississippi, and Uniontown, Pennsylvania, and approximately 40 miles of new lateral supply lines.

The Penn-Jersey system was authorized to construct and lease to Texas Eastern the following additions to existing or authorized compressor stations along its system: 4000 hp at Delmont station, Westmoreland County, Pennsylvania; 5000 hp at Lilly station, Cambria County, Pennsylvania; 5000 hp at Perulack station, Juanita County, Pennsylvania; 5000 hp at Grantville station, Dauphin County, Pennsylvania, and 5000 hp at Bechtelsville station, Berks County, Pennsylvania.

Construction is expected to be completed in time to begin operations of the new facilities by September 1, 1957, Carpenter said.

Transco Begins Work on A $54,000,000 Project

Construction has begun on a new phase of the program to bring more natural gas to the New York City-New Jersey-Philadelphia metropolitan area, E. Clyde McGraw, president of Transcontinental Gas Pipe Line Corporation, announces.

Significant portions of a $54,000,000 expansion project were given a green light by the Federal Power Commission issuing a temporary certificate allowing start of construction. Allocations this winter to the metropolitan area will be more than 83,000,000 cu ft.

Included in the project are 247 miles of new purchase laterals, mostly 24-in. and 16-in., to reach large new reserves committed to Transco in an area of Texas not now reached by big-inch transmission companies. Not only are the estimated reserves large, but the new pipeline outlet for natural gas in these fields south of San Antonio has already stimulated extensive additional exploration in three counties. The potential is considerably greater than reserves in the area already dedicated to Transco, McGraw said.

The temporary certificate also includes 57 miles of 36-in., and 30-in. main line "loops" in Louisiana, Mississippi, Alabama, Georgia, and South Carolina; three new main line compressor stations, one in North Carolina and two in Virginia; additional compression horsepower at existing stations in Texas, Louisiana, and Pennsylvania, and eight new dehydration installations in connection with the new gas reserves in Texas.

Ohio Fuel Given Permit for Expansion

The Ohio Fuel Gas Company has received authority from FPC to build approximately 55 miles of pipeline and 3000 hp in additional compressor capacity in Jackson, Lawrence, Fairfield, and Licking counties, Ohio.

The application covers the construction of about 37.7 miles of 24-in. line paralleling an existing line from Ohio Fuel's Crawford compressor station in Fairfield County to its Treat station in Licking County.

Ohio Fuel also proposes to build approximately 17.2 miles of 20-in. line, which will extend an existing line southward from its terminus in Jackson County to the company's Symmes compressor station in Lawrence County. This extension also will parallel a portion of an existing line.

In addition, Ohio Fuel plans to install an additional 3000 hp in compressor capacity at its Crawford station.

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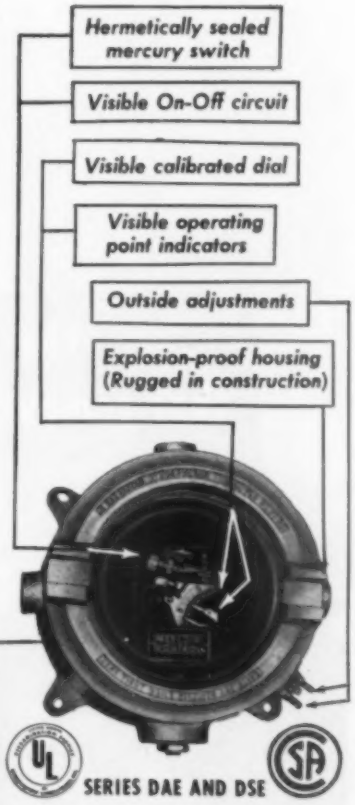

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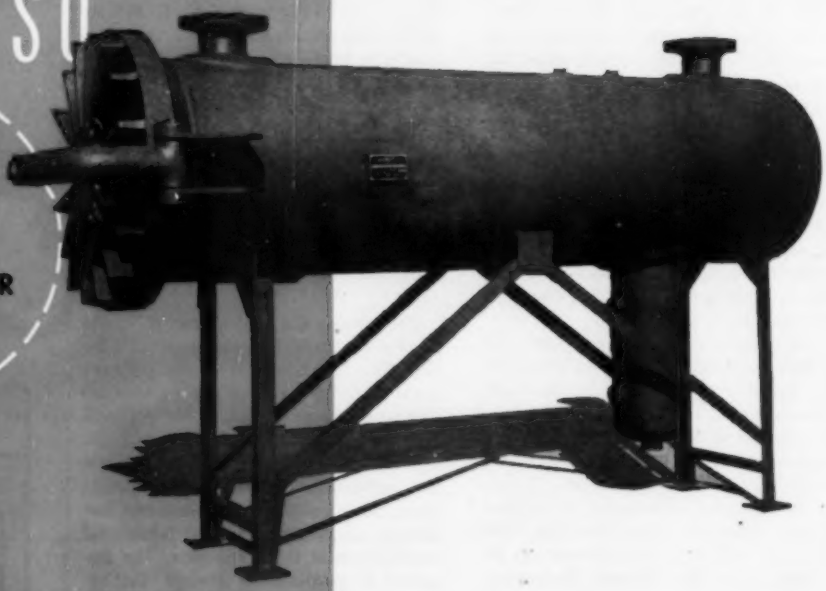

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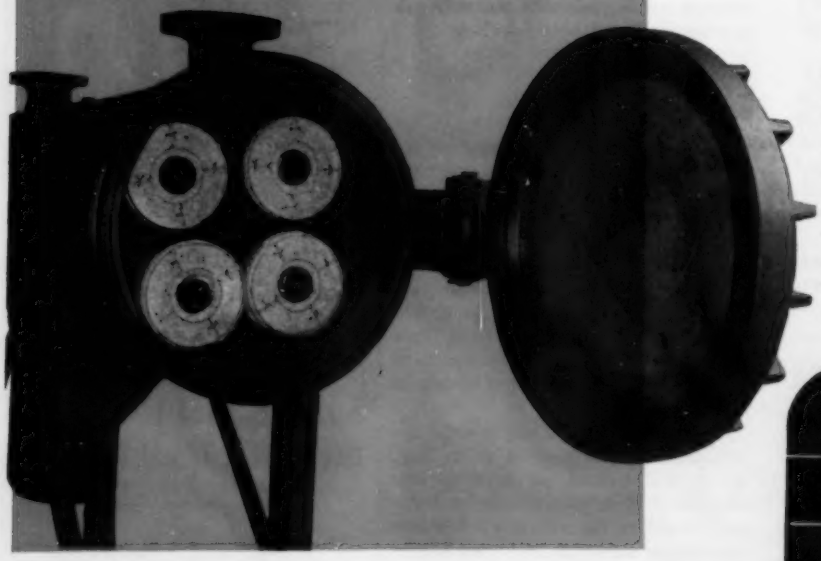

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CATC Group Contracts 30-Mile Offshore Line

Plans to construct a 25-mile undersea pipeline system for the CATC Group, which will extend from a point near Grand Isle, Louisiana, to three self-contained platforms in the Grand Isle offshore area, have been announced by Continental Oil Company.

Conoco serves as operator for the CATC Group, which also includes Atlantic Refining Company, Tidewater Oil Company, and Cities Service Production Company. As operator for CATC, Conoco will supervise the construction of the 12-in. line.

Marine Gathering Company, a division of Commonwealth Oil Company of Houston, has been awarded the contract to construct the line. Completion is scheduled for about September 1.

The line will be designed to transport both crude oil and gas, which will be separated at a terminal at Grand Isle. It will have an ultimate capacity of some 45,000 bbl of crude oil daily and will be coated with reinforced concrete to provide sufficient weight to keep the line from floating.

Submarine pipeline trenching work on the project will be handled by Collins Construction Company of Port Lavaca.

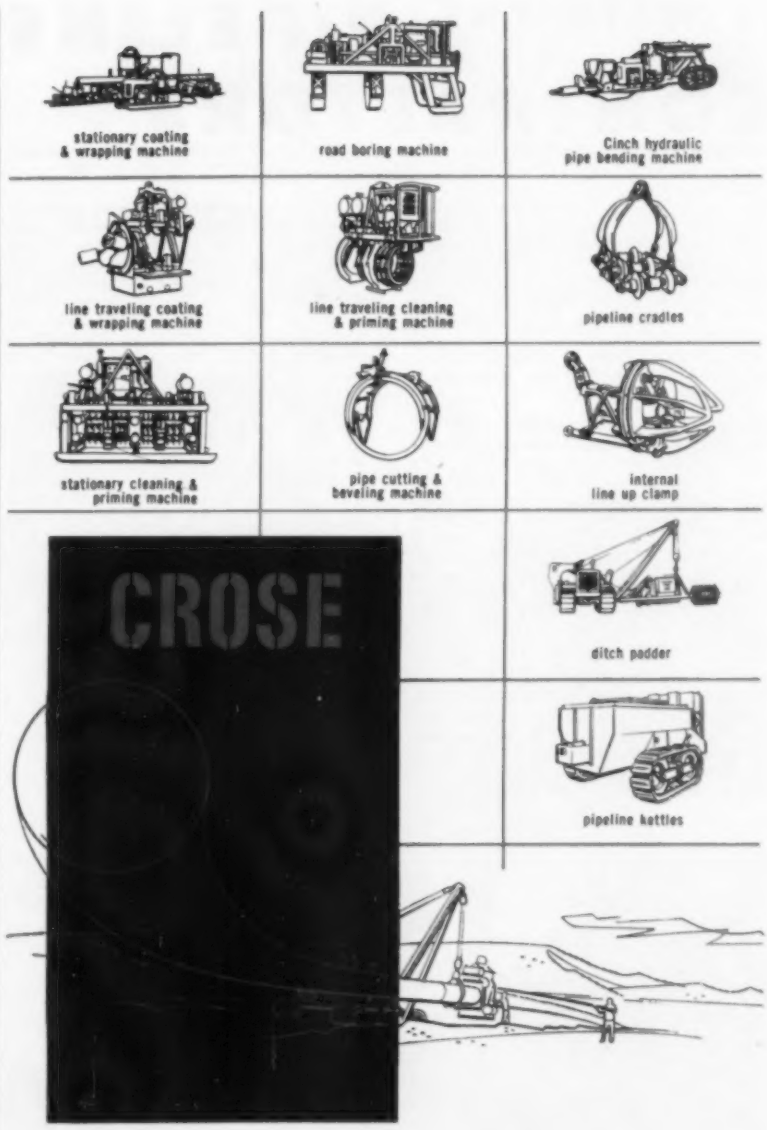
PG&E Is Completely Looping Its System

Pacific Gas and Electric Company's 34-in. transmission line importing out-of-state natural gas, will be completely doubled over its 502-mile length by the end of this year, the company disclosed in announcing the award of a contract for the final 138 miles of "looping." The announcement was made by N. R. Sutherland, president and general manager of the company, who said the project will cost more than $15,000,000.

The principal contract was awarded to Engineers Limited Pipeline Company. In associated work, the horsepower of 6 of the 10 compressors at Topock compressor station will be increased from 2500 hp each to 3500 hp. Other improvements will be made at the Hinkley and Kettleman stations.

Conversion of four compressors at Hinkley and one at Topock plus addition of one compressor at Topock in 1958 will increase the deliveries to 1,025,000,000 cu ft of gas daily.

The 138-mile construction will be started with a 30-mile job in San Bernardino County extending easterly from Danby. The second section will be 68.8 miles from Oak Creek Pass to Hinkley, north of Mojave. The third portion will be a 39.2-mile stretch in the western San Joaquin Valley from Kettleman to Panoche.



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WITH THE PIPELINE CONTRACTORS

● **A. P. Vaughn Construction Company, Box 1144, Fort Worth, Texas.** Has joint venture with Potashnick Construction Company to lay sections 1 and 2 of the Utah to California crude line for *Four Corners Pipe Line Company*. Both sections are 16-in. pipe. Section 1 is 76 miles from the Aneth field in Utah to Kayenta, Arizona; section 2 runs 98 miles from Kayenta to Cameron, Arizona. Work began June 15.

● **Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.** Has contract for laying 37,000 ft of 22-in. pipe for the *City of Los Angeles*, California. Line will serve as ocean outfall for sludge from Hyperion Treatment Plant at El Segundo, and will extend from El Segundo beach to a depth of 300 ft in the Pacific Ocean. Also has 11,000 ft of 4-in. pipe to lay for *Pan American Petroleum Corporation* from McFaddin Beach Dome near High Island to a producing well offshore in the Gulf of Mexico.

● **Somerville Construction Company, Ada, Michigan.** Has 67 miles of 10 and 12-in. line from Clare County to Traverse City, Michigan, for *Michigan Consolidated Gas Company*. Also has 60 miles of 10 and 12-in. line between Muskegon and Ludington, Michigan, for the same company.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has 212.5 miles 20-in. crude line for *Socony Mobil Oil Company de Venezuela*. Line will extend from San Silvestre field to Puerto Cabello on the Caribbean Coast. Also has 127 miles of 30-in. loops for Texas Eastern Transmission Corporation; work is divided into three jobs from Egypt, Mississippi to Barton, Alabama; Berne, Ohio to Holbrook, Pennsylvania; and Holbrook to Uniontown, Pennsylvania.

● **C. P. Bartley & Son Pipe Line Construction, P. O. Box 616, Tioga, North Dakota.** Has 110 miles of 3 through 12-in. gas gathering extensions for *Signal Oil & Gas Company* in the Newton, North Dakota, area.

● **Houston Contracting Company, 2707 Ferndale Place, Houston 6, Texas.** Has 43 miles of 30-in. natural gas line for *Texas Eastern Transmission Corporation* between Berne and Athens, Ohio. Also has 35 miles of 30-in. gas line for *Texas Eastern* between Wheelersburg and Athens, Ohio. Has 80 miles of 30-in. gas line for *Texas Eastern* from Kosciusko to Egypt, Mississippi. Has 80 miles of 30-in. natural gas line for *Northern Ontario Pipe Line Crown Corporation* between Uspala and Port Arthur, Ontario.

● **Hood Construction Company, 3002 E. Century Blvd., Lynwood, California.** Has 81 miles of 10-in. line for *Southern Pacific Pipe Lines, Inc.*, beginning west of Lodi and running to a point near Roseville, California; this is second section of firm's 323 mile products line.

● **J. E. Young, Pipe Line Contractor, Inc., 931 E. Rosecrans Avenue, Los Angeles, California.** Has joint venture with Engineers Limited on two sections of the 323 mile *Southern Pacific Pipe Lines, Inc.*, new products line. Contract includes 184 miles of 6 and 8-in. line extending from Roseville, California, to Fallon, Nevada.

● **Dutton-Williams Bros., Ltd., North Canadian Oils Building, Calgary, Alberta.** Has approximately 320 miles of distribution and transmission systems for *Inland Natural Gas Company* in and connecting several British Columbia towns. Project includes 154.5 miles of 12 in. line, 110 miles of 10 in., and remainder from 8 to ¾-in. in Nelson, Savona, Penticton, Castlegar, Kelowna, Kamloops, and Grand Forks. Also has contract for 47.5 miles of 12-in. oil line from Gilbey to Sundre for *Rangeland Pipe Line Company*. Has contract for testing 310 miles of *Westcoast Transmission, Ltd.*, 30-in. line from Taylor, B. C., to M. P. 310; completion is expected in September. Has contract for 50.8 miles of 30-in. oil line for *Trans Mountain Oil Pipe Line Company* between Edson and Minton, Alberta.

● **Fish Service Corporation, M & M Building, Houston, Texas.** Has 67 miles of line for *Florida Pipeline and Storage Company* from Port Everglades to Homestead Air Force Base, Florida.

FOR OVER 20 YEARS the versatile Cleveland "110"...here's one working on a gas gathering line for Phillips Petroleum in McClain County, Okla.... has been a fast dependable trencher on gas, oil, and product pipelines of all types, to 24 inches wide and 5½ feet deep ... trunk lines, gathering lines, field lines, lease lines. Built tough and compact, the "110" is a perfectly balanced combination of practical, performance-proved features ... a trencher of superior digging ability in all types of soil and terrain. It digs more trench in more places at less cost.
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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Contractors

● **A. J. Curtis & Company, P. O. Box 1072, Casper, Wyoming.** Has undetermined amount of ¾ to 6-in. city distribution line to lay for *Spokane Natural Gas Company*.

● **Banister Construction, Ltd., 625 Northern Hardware Bldg., Edmonton, Alberta.** Has undetermined amount of 2 to 6-in. extensions to existing systems in cities and towns in Saskatchewan, plus approximately 5000 consumer service connections, for *Saskatchewan Power Corporation*. Also has contract for 25 miles of 10-in. line from the Trans-Canada pipeline to the City of Brandon, Manitoba, for *Plains-Western Gas & Electric Company;* this project includes installation of approximately 3000 consumer service connections.

● **H. C. Price Company, Box 1111, Bartlesville, Oklahoma.** Has 71 miles of 30-in. line for *Texas Eastern Transmission Corporation* in the Port Lavaca, Texas, area. Has contract for construction of 343 miles of 30-in. pipeline loops for same company, consisting of six jobs in Tennessee, Kentucky and Ohio.

● **Sheehan Pipe Line Construction Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has 116 miles of 8-in. line for *Buckeye Pipe Line Company* between Huntington and Griffith, Indiana; project includes take-up, reconditioning and relay. Also has 70 miles of 8-in. line to recondition for *Buckeye Pipeline Company* near Cooks Ferry, Ohio.

● **Canadian River Construction, 580 Hornby Street, Vancouver, British Columbia.** Has 150 miles of gathering lines in northern Alberta and British Columbia for *Westcoast Transmission Company, Ltd.*

● **Ted Price Construction Company, Electra, Texas.** Has 205 miles of 1 to 8-in. distribution system in Walla Walla, Washington, and Pendleton and Baker, Oregon for *Cascade Gas Company*. Also has 20 miles of 8-in. line to lay for *Sinclair Oil & Gas Company* between the Slocum area, Anderson County, Texas, to Palestine.

● **Troth Construction Company, Box 592, Britton, Oklahoma.** Has contract for 160 miles of 2 and 8-in. lines for gas distribution to communities in the Aberdeen, South Dakota, area, for *Northern Natural Gas Company*.

● **Fulton Banister, Ltd., 625 Northern Hardware Building, Edmonton, Alberta.** Has 100 miles of 18-in. and 17 miles of 34-in. line for *Alberta Gas Trunk Line Company, Ltd.*, running from Burstall at the Alberta border to Provost, Alberta. Also has 22 miles of gas gathering line in the Provost field for Provo Gas Producers, Ltd., consisting of constructing gathering system and wellhead tie-ins—3 to 12-in. pipe; this gas to be fed to Alberta Gas Trunk Lines.

● **Engineers Limited Pipeline Company, 200 Bush Street, San Francisco, California.** Has line for *Pacific Gas & Electric Company* consisting of 37 miles of 20-in., 37 miles of 18-in., and 19 miles of 12-in. to lay from Beehive Bend field to Sacramento, California. Has joint venture with J. E. Young, Pipe Line Contractor, Inc., on two sections of *Southern Pacific Pipe Lines, Inc.*, new products line. Contract involves 184 miles of 6 and 8-in. line between Roseville, California, and Fallon, Nevada. Also has joint venture with Alex Robertson Company to construct 165-mile, 12-in. gas line for Pacific Gas and Electric Company from Tehama Count to Humboldt Bay area.

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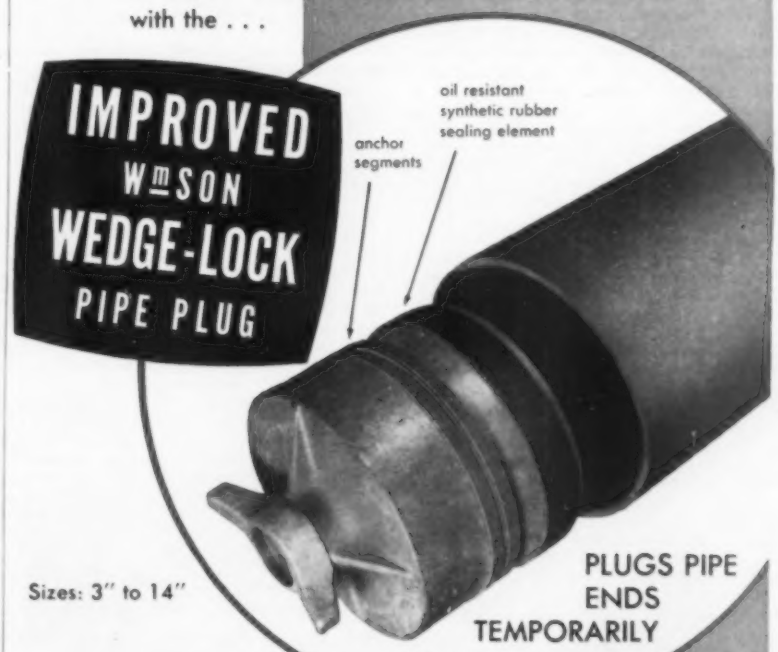
- Add Fittings
- Propel Pigs by Compressed Air

with the . . .

IMPROVED Wm SON WEDGE-LOCK PIPE PLUG



Sizes: 3" to 14"

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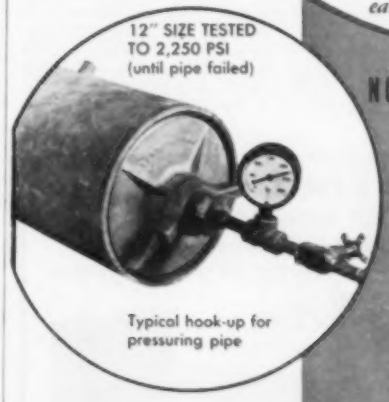

NOTE THESE IMPROVEMENTS:

- ★ Each size seals in greater range of pipe ID's
- ★ Independent anchor segments insure uniform grip inside pipe
- ★ Large bypass hole through center
- ★ Rugged sealing element
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Contractors

● **Mannix, Ltd., 322 Seventh Avenue W., Calgary, Alberta.** Has 100 miles of 3 to 12-in. gathering line in the Pembina field to lay for *Pembina Pipeline Company, Ltd.* Has 110 miles of 30-in. for *Westcoast Transmission Company, Ltd.*, between Huntingdon and Kingsvalle, British Columbia. Has 90 miles of 34-in. to lay for *Trans-Canada Pipe Line Company* between Moose Jaw and Candiac, Saskatchewan. Has contract to lay 32 miles of 16-in. loop for *Pembina Pipe Line Company, Ltd.*, between Edmonton and Calmar, Alberta.

● **Mid-States Construction Company, P. O. Box 417, Mt. Vernon, Illinois.** Has 24 miles of ¾ to 6-in. distribution line for *Illinois Power Company* for systems in Carlyle and Hoffman, Illinois. Also has 8½ miles of 6 and 4-in. line for the same company between Hoffman and Carlyle.

● **Potashnick Construction Company, Box 423, Cape Girardeau, Missouri.** Has joint venture with A. P. Vaughn Construction Company to lay sections 1 and 2 of *Four Corners Pipe Line Company* crude line between Utah and California. Both sections are 16-in. pipe; section 1 is 76 miles from the Aneth field in Utah to Kayenta, Arizona; section 2 runs 98 miles from Kayenta to Cameron, Arizona. Work on both sections began June 15.

● **Williams-Austin Construction Corporation, 3322 Grant Building, Pittsburgh 19, Pennsylvania.** Has 50 miles of 10-in. for *Central Hudson Gas & Electric Company* between Kingston and Albany, New York. Also has 5.7 miles of 26-in. line for Atlantic Seaboard Corporation in Hardy and Grant counties, West Virginia.

● **Latex Construction Company of Georgia, Box 56, Northside Branch, Atlanta, Georgia.** Has contract, beginning June 15, for 46 miles of 24-in. line for *Michigan Wisconsin Pipe Line Company*. Line extends southwest from a point near Milwaukee, Wisconsin. Also contract from city of Jacksonville, Florida, for laying 6 miles of 6-in. oil static electric transmission conduit pipeline within the city of Jacksonville. Also has 15 miles of 8-in. distribution service line for *South Atlantic Gas* in Savannah and Chatham counties, Georgia.

● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Has 8 miles of 20-in. to take up in the vicinity of Roland, Arkansas, for *Magnolia Pipeline Company*. Has completed laying a similar amount of new line paralleling take-up job. Has contract for 185 miles of 20-in. crude line for the *Tecumseh Pipe Line Company* to extend from Scherville, Indiana, to Cygnet, Ohio. Has contract for 44 miles of 24-in. line between Sugar Grove and Homer, Ohio, for the *Ohio Fuel Gas Company-Columbia Gas System*. Has been awarded contract to lay 120 miles of 16-in. and 4 miles of 12-in. crude line for *Magnolia Pipe Line Company* between Abilene and Midland, Texas; this project will not begin till late summer.

● **Dunn Bros., Inc., 801 Mercantile Securities Building, P. O. Box 5771, Dallas, Texas.** Has 105 miles of 34-in. for *El Paso Natural Gas Company* between St. Michaels and Navajo Station, Arizona. Has 145 miles of 34-in. line for *Western Pipe Line Company* east of Flagstaff to Topock, Arizona.

● **R. H. Fulton & Company, Inc., P. O. Box 1526, Lubbock, Texas.** Has 252 miles of 22-in. line for *Colorado Interstate Gas Company* between Rock Springs and Laramie, Wyoming. Has 78.4 miles of 26-in. line in the Minnesota section of *Interprovincial Pipe Line Company's* main line loop. Has contract for sections 3, 5 and 6 of the new *Four Corners Pipe Line Company* line. Section 3 is a 16-in. line 98 miles long from Cameron to Seligman, Arizona; this work began July 1. Sections 5 and 6 are to begin October 15 to avoid crossing desert during hot summer. Section 5 is 105 miles of 16-in. line from the Colorado River to Twentynine Palms, California and section 6 is a 46-mile 16-in. section from Twentynine Palms to Olive, California. Also has 93 miles of 8-in. for Great Lakes Pipe Line Company from Newport, Minnesota to Chippewa Falls-EauClaire, Wisconsin area.

● **Engineering-Construction Company, First National Bank Building, Tulsa, Oklahoma.** Has contract with *Northwestern Public Service Company* to lay distribution systems in four towns in South Dakota, also has extensions in another South Dakota town. Field office has been set up in DeSmet; work started April 15.

● **F. E. Shaw, Ltd., 530 S. Vidal Street, Sarnia, Ontario.** Has 40 miles of 6 to 10-in. line for *Dominion Natural Gas Company, Ltd.*, in the Brantford, St. Catharines, and St. Thomas districts. Has 8 miles of 16-in. line for *Dow Chemical of Canada, Ltd.*, from new salt bed location to the Sarnia district. Has 14 miles of 16-in. loop line around the city of Hamilton, Ontario, for *United Gas and Fuel Company*. Has 67 miles of 6 to 20-in. transmission lines for Union Gas Company, Chatham, Ontario, to Dawn, London, St. Marys, Stratford, Kitchener and Guelph. Has 12 miles of 2, 4, 6, and 8-in. distribution line for the *Consumers Gas Company* of Toronto in the town of Newmarket, Ontario.

● **Price-Poole Pipeline Constructors of Canada (joint venture of H. C. Price of Canada Limited and Poole Construction Company, Ltd., Rivers, Manitoba.** Has 99-mile section of 34-in. pipe to lay for *Trans-Canada Pipe Line Company* on a section of line in Manitoba Province extending eastward from the Assiniboine River near Miniota. Right of way has been cleared and limited activity is underway prior to actual construction beginning this spring as weather permits.

● **Sheehan Constructors of Canada, Ltd., Toronto, Ontario.** Has joint venture with Robert B. Somerville Company, Ltd. for 91 miles of 20-in. line between Bright and Sarnia, Ontario, for *Interprovincial Pipe Line Company*.

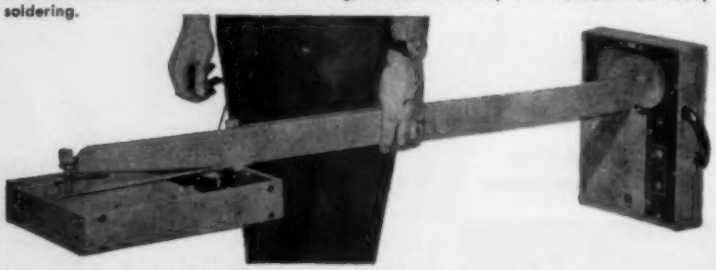
● **Robert B. Somerville Company, Ltd., 4891 Yonge Street, Toronto, Ontario.** Has joint venture with Sheehan Constructors for 91 miles of 20-in. line between Sarnia and Bright, Ontario, for *Interprovincial Pipe Line Company*. Job started May 13.

● **Eastern Pipeline Contractors, Mercantile Bank Bldg., Dallas, Texas.** Has contract for 89 miles of 6 and 8-in. line for *Gulf Refining Company*, from a point westward from Midland into New Mexico, near Hobbs.

The WILKINSON LINE LOCATOR
PREVENTS COSTLY DAMAGE

Spots all sub surface pipes, cables, etc., and determines their depth accurately.

ETCHED CIRCUITRY: instead of hand wiring, insures uniformity and freedom from faulty soldering.



BATTERY TESTER: instantly indicates battery condition without removing batteries.

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Temporary Authority Granted Northern Natural

Northern Natural Gas Company has been granted temporary authority to construct and operate natural gas facilities in Hansford County, Texas, at an estimated cost of $1,982,000.

Northern proposes to construct 12.7 miles of 16-in. line to replace an existing 10-in. line; to boost the capacity of its Spearman dehydration facilities by 50,000,000 cu ft per day; and to construct certain additional field line and measurement facilities.

Michigan Gas Will Add to Station's Power

Michigan Gas Storage Company, of Jackson, Michigan, has been given temporary authorization to add 3800 hp to its Muskegon River compressor station, increasing that station's capacity to 25,200 hp and to improve its Winterfield and Cranberry Lake storage fields by drilling new wells, constructing about six miles of 6 and/or 8-in. gathering pipeline and various 4-in. well lines.

● **Oklahoma Pipe Line Constructors, P. O. Box 13227, Dallas 20, Texas.** Has 35 miles of 30-in. for *Tennessee Gas Transmission Company* between a point in Garrard County, Kentucky, to a point of TGT's compressor site in Powel, Kentucky. Also has 85 miles of 20 and 24-in. (spread 101) of Trans-Canada Pipe Lines, Ltd., on the eastern section, in proximity of Toronto, Ontario, beginning from a point southwest of Toronto circling the city, and also a section beginning at a point east or northeast of Toronto.

● **Brown & Root, Inc., 4100 Clinton Drive, Houston, Texas.** Has contract with *Texas Eastern Transmission Corporation* to furnish field supervision for construction of 626 miles of 30-in. loops along the company's line between Beaumont, Texas, and Uniontown, Pennsylvania.

● **Midwestern Contractors, Inc., 130 West Liberty Drive, Wheaton, Illinois.** Has contract for 69-mile, 12-in. extension of *Great Lakes Pipe Line Company* line from Middlebury Junction into Chicago, Illinois.

● **Majestic Contractors Limited, 408 Royal Trust Building, Edmonton, Alberta.** Has an 82-mile 30-in. spread for *Trans-Canada Pipe Lines*, Ltd., from St. Anne, Manitoba, to the Ontario border. Also has contract for testing a 34-in. spread of the Trans-Canada line between Burnstall, Saskatchewan and Winnepeg, Manitoba. Has 65 miles of 20-in. line for *Interprovincial Pipeline, Ltd.*, between Sarnia and Port Credit, Ontario. Has contract for 4 to 12-in. gathering system for *Producers Pipeline, Ltd.*, in the Estavan, Saskatchewan area. Has city distribution system in Cooksville, Ontario, for Consumers Gas Company of Toronto. Also has city distribution system for Guelph, Ontario, for *Union Gas Company of Canada, Ltd.*

● **Midwestern Constructors, Inc., 105 North Boulder, Tulsa 3, Oklahoma.** Has 34 miles of 12-in. paralleled line for *Great Lakes Pipe Line Company* between Tulsa to Barnsdall, Oklahoma.

● **Jess Whitlow Pipe Line Service, 1415 West Highland Street, Ponca City, Oklahoma.** Has 15.6 miles of 8-in. to replace existing 4-in. line for *Great Lakes Pipe Line Company* between Coffeyville to Independence, Kansas.

Texas Eastern Contracts Huge Expansion Work

Texas Eastern Transmission Corporation has awarded contracts for construction of some 626 miles of 30-in. loop pipelines and addition of approximately 55,600 compressor hp along the company's 30-in. trunk line between Beaumont, Texas, and Uniontown, Pennsylvania. Authorization for the construction is under FPC Docket Nos. G-9784 Part A and Part B, and G-12227.

The loop lines and increases in compressor horsepower are being added to Texas Eastern's natural gas system as the final part of a program to expand daily delivery capacity by approximately 360,000,000 cu ft and increase the capacity of the company's 30-in. trunk line by an additional 200,000,000 cu ft daily to absorb the volume of natural gas previously carried by the Little Big Inch pipeline.

In addition to construction of the loop pipelines, the work will include constructing four new compressor stations and adding compressor horsepower at six other stations. When work is completed, Texas Eastern's natural gas system will consist of some 5900 miles of pipe in service and approximately 549,000 compressor hp.

Brown and Root, Inc., of Houston, Texas, will provide field supervision for construction of the 30-in. pipeline loops and will construct a new 15,200-hp station at Gillis, Louisiana; a new 15,200-hp station at St. Francisville, Louisiana, and a new 15,200-hp station at Clinton, Mississippi.

H. C. Price Company, Bartlesville, Oklahoma, was awarded a contract for construction of approximately 343 miles of pipeline loops; Williams Brothers Company of Tulsa, Oklahoma, a contract for construction of approximately 127 miles of 30-in. loops, and the Houston Contracting Company, Houston, Texas, a contract for construction of approximately 156 miles of 30-in. loops.

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NBS Method Permits

Rapid Screw Thread Pitch Measurement

Pitch of internal screw threads can now be measured rapidly without sacrifice of high accuracy required in NBS developed technique

A technique recently developed by C. E. Haven of the National Bureau of Standards permits rapid measurement of the pitch, or lead, of internal screw threads without sacrifice of the high accuracy required in this work. The NBS method can be used to determine taper or ring gages at the same time as lead and is adaptable to measurements in very small ring gages, which have hitherto presented a considerable problem. For straight-thread ring gages, the technique had the added advantage that straightness of the bore can be determined simultaneously with lead, thus providing a quick assessment of the amount of wear at the ends of the gage.

In connection with the program of the American Petroleum Institute for standardization of the threaded connections on oil field equipment, the National Bureau of Standards calibrates master threaded gages used by the petroleum industry for calibration of working standards. This is done through the use of thread measuring instruments whose calibration is ultimately based on the national standard of length maintained by the Bureau.

Because the standardized API threaded joints cover such an extensive range of sizes — ⅛ to 20-in. in diameter and up to 6-in. of threaded length — the measurement of some elements of the threads is beyond the range of commercially available measuring equipment, and the National Bureau of Standards and the manufacturers of API gages have had to design special equipment for this purpose. Until now, NBS equipment for determination of lead has required the use of two series of equal combinations of gage blocks for measurement of the interval, and the procedure involved has been rather time-consuming.

The more rapid method developed by NBS for measuring lead makes use of a taper testing machine constructed by Pratt and Whitney Division of Niles-Bement-Pond Company. This device consists primarily of an adjustable sine plate on which the gage to be tested is mounted, and a carriage that travels on accurately machined ways to move a ball-point probe in and out of the mounted gage.

When the angle between the sine plate and a normal to the plane of the ways is equal to one-half the taper angle of the gage under test, the pitch line at the bottom of the gage (provided the taper of the gage is straight) will be parallel to the ways. As the carriages move along the ways, the small ball on the end of the probe contacts the flanks of the threads in the ring gage. If the taper of the gage is true, the ball will remain at the same elevation above the ways as the probe moves from thread to thread. Variations in the elevation of the probe, caused by error in taper, are read on an electrically actuated meter.

The National Bureau of Standards has extended this procedure to permit use of the same settings of the probe to determine lead as well as taper. The NBS method for lead determination involves measurement of the movement of the carriage through the use of a glass scale graduated in increments of 0.050 in. over a range of 4 in. The glass scale moves with the carriage, and the position of the scale is observed with a microscope having four reticle graduations, each equivalent to 0.01 in. on the scale. A scale graduation is brought into apparent coincidence with the nearest reticle graduation by rotating a plane parallel plate of optical path of the microscope.*

This parallel plate constitutes a kind of "optical micrometer," that is, the shaft on which it rotates carries a graduated drum having 200 divisions for each 0.01 in. of apparent motion of a scale graduation. This gives a least reading of 0.00005 in. and permits estimation of fifths of divisions. The scale is accurate to $\mp$ 0.00002 in. in 1 in. and $\mp$ 0.00004 in. in 4 in.

For accurate measurement of lead, the motion of the carriage must be substantially free from friction. This is accomplished by having the carriage roll on ¼-in. steel balls located in suitable guides. The lower surfaces of these guides are formed by two parallel V-grooves, approximately 3¼-in. apart, running along the entire upper surface of the base on which the carriage travels. The corresponding upper surfaces of the 2 guides are formed by a single V-groove and a flat surface that runs along the underside of the carriage.

By viewing a mirror on the carriage with an autocollimating telescope, it is possible to determine deviations from linear motion of the carriage quite accurately and to make such adjustments of the ways as are necessary to obtain practically straight-line motion of the carriage.

The modified instrument has proved highly satisfactorily at NBS for rapid, accurate measurement of the lead of both straight-thread and tapered ring gages. Special probes have been used for measurement of very small thread ring gages. The instrument has also been used to measure the lead of thread ring gages up to 3 in. in diameter. In general, the repeatability of the readings has been found to be as good as the precision with which the scale can be read, that is, between 0.00001 and 0.00002 in. ★ ★ ★

*A measuring device manufactured by Hilger and Watts, Ltd. (London), is used.

NEW MOTOROLA T-POWER 2-WAY RADIO

Transistorized Power Supply for both receiver and 25-watt transmitter

Long Life Transistors Replace the Vibrator . . .
Reduce Maintenance and "Down-Time"

Already famous for the lowest maintenance and operating costs in the 2-way mobile radio field, Motorola mobile radio is an even better investment now—with the T-POWER unit. The vibrator is gone! . . . replaced by rugged long-life transistors. Gone, too, is the problem of frequent vibrator replacement. Here is a mobile radio with an all-electronic power supply.

New Mounting Flexibility with Plug-In Control Head
. . . Same Basic Unit can be Used for Front or Trunk Mounting

With the T-POWER radio, you are no longer restricted to one type of mounting. Install the complete radio, with drawer unit and plug-in control head, for under-dash mounting. For rear mounting the same basic drawer unit can be installed in the trunk and connected by cable to a dash-mounted control head. And—the same basic drawer unit can be interchanged with the equivalent Motorola Twin-V trunk mount radio models operated from a 12-volt negative ground source.

T-POWER radio is another example of Motorola's continuing leadership in the practical application of transistors in mobile radio. Other tested and proved transistorized products include the Dynamic Microphone and Power Voice Speaker.

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NEW Pipeline Equipment

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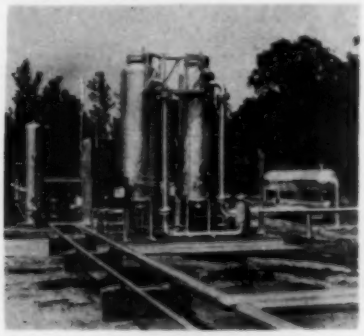
For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Unit Recovers Raw Gasoline. A new type of processing unit that will recover thousands of barrels a day of raw gasoline previously lost in natural gas streams, trade-named the "Dryex", is a fully automatic, packaged adsorption unit designed primarily for use on relatively small and lean natural gas streams. A full scale pilot unit has been operating since February on a co-operative trial installation



with Texas Gas Corporation. The "Dryex" units recover more than 85 percent of commercially valuable liquids contained in the natural gas streams.

The "Dryex" consists primarily of 2 vertical adsorption towers, a vessel in which recovered liquids are stored, a Delta heat exchanger, a direct-fired gas heater, piping, 3-way valves and a gas pump. Three-way valves direct the main stream flow through first one and then the other tower while 2 of the other valves send the regenerative gas through the alternate towers.

Units will vary from $800 to $1400 per bbl of daily recovery capacity according to their size. Units designed to recover 40 bbl of raw gasoline daily will be priced at approximately $50,000. Unit cost decreases for larger "Dryex" assemblies and increases for those with smaller daily recovery capacities. *Delta Tank Manufacturing Company, Inc.*

Circle number (81) on reply card.

Angle Dozer Attachment. A new angle dozer attachment for the Davis Loader is announced by Midwestern Industries, Inc. With this attachment the operator

can back fill by "shaving in" the dirt while running parallel to the ditch. *Midwestern Industries, Incorporated.*

Circle number (82) on reply card.

250 HP Turbocharged Power Unit. International Harvester has entered the turbocharged engine field with the 250 hp Turbotorque UDT-1091 power unit. This 250 brake hp is attained at 1500 rpm, an increase of 50 hp over its naturally-aspirated counterpart, the UD-1091. The new 6-cyl unit has all the features that have made the UD-1091 a favorite, plus the cost-cutting, dependable-adding advantages inherent in its turbocharger components.

Its exhaust gas driven AiResearch turbocharger moves 60 percent more air through the big 14-in. diam air cleaner. This tremendous boost in air supply to the cylinders results in an economy-saving cut in fuel consumption and higher power with lower exhaust gas temperatures. *International Harvester Company.*

Circle number (83) on reply card.

Mobile Map Rack. Ross-Martin announces a new lightweight, mobile map rack on double ball-bearing, rubber-tired casters. Rigidly constructed of welded angle iron, sheet metal, and steel rods, the Model V-80 is designed for use by draftsmen in the working area as well as a mobile file. The V-80 (size 49⅜ by 16⅜ in.) accommodates 80 maps of any size. Metal-end telescope tubes to be used together for dust-proof filing or singly as open end filing are available. *Ross-Martin Co.*

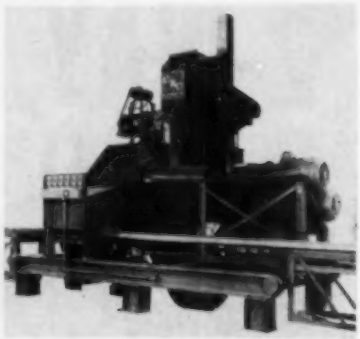
Circle number (84) on reply card.

Low Cost Computers. The Readix Dual Computer was designed to handle research and development problems as well as process business data for small and intermediate firms and organizations. It has proved a flexible, easy machine to program and operate when handling research and development problems—for it is a pure decimal machine with built in

floating point. Now, the small and intermediate firm or organization which cannot justify a computer for just research work—can have a Readix Dual Computer—with the punched card and magnetic tape tie-in so they can do payroll, labor distribution, sales analyses, etc., and take a load off the card equipment as well as handle the research work. *J. B. Rea Company.*

Circle number (85) on reply card.

Machine Cleans 90-ft Pipe per min. Crutcher-Rolfs-Cummings, Inc. is building grit-blast pipe cleaning machines for stationary yards. Termed the CRC Auto-Blast Pipe Cleaning Machines, they are capable of thoroughly cleaning pipe up to 90 lineal ft per min in automatic succession.



Two models are available: ¾ to 12-in. pipe size and 6 to 36-in. pipe size. In operation, heavy, industrial steel grit is blasted on the pipe surface at 14,000 ft per min velocity, in a controlled pattern. The Auto-Blast handles up to 2500 lb of grit per min. Grit is reused in a continuous cycle. *Crutcher-Rolfs-Cummings, Inc.*

Circle number (86) on reply card.

Machine Cuts Large Pipe. A newly designed machine capable of cutting 20 in. and larger pipe, with a cut surface finish suitable for gasket face use, can handle 40 ft lengths of pipe with wall thickness of ⅞-in. or heavier provided the first cut

is 5 ft or more. Controls to move the chucking drive up and down for centering is hydraulic, as is the locking system which holds the chuck in proper position. Movement of the chucking device back and forth is electrical as are the rotation and cutting units. Larger sizes will be made to order. *Wallace Supplies Mfg. Co.*

Circle number (87) on reply card.

Liquid Detergent for Steam Cleaning. Oakite LSD, a new liquid detergent designed for use in solution lifting steam guns and self generating steam cleaning equipment, has been introduced by Oakite Products, Inc.

Developed to simplify the preparation of steam cleaning solution and to reduce the clogging of coils in self generating equipment, it will handle a wide variety of steam cleaning operations ranging from light to medium-heavy duty. *Oakite Products, Inc.*

Circle number (88) on reply card.

Leak Detector. A newly-improved electronic leak detector—so sensitive it can detect one part of helium in 2 million parts of air—has been announced by General Electric's Instrument Department. Based on an original development for the wartime Atomic Energy Program, the re-designed mass spectrometer leak detector features extreme sensitivity, fast response, and high resolution.

Ten times more sensitive than its predecessor, the new M-2 leak detector finds and locates leaks in vacuum or pressure systems. It is used by electronic industries, nuclear developments, military units, and research laboratories for quality control and production checks. *General Electric Company.*

Circle number (89) on reply card.

Composition Disc Check Valve. A new renewable composition disc bronze swing check valve has been added to the Fairbanks line of bronze and iron body valves. Swing check valves are generally recommended for service on liquid lines where full unobstructed flow or minimum resistance to flow is desired. Renewable composition discs protect the valve seat from damage due to solid particles in the steam and from the shocks or pulsating pressures affording considerable savings in replacement costs to users. Discs can be replaced without removing the valve body from the line. Composition discs are regularly furnished in a medium-hard type for liquid service and steam discs are also available. *The Fairbanks Company.*

Circle number (90) on reply card.

Length of Bellows Reduced. Robertshaw-Fulton has developed a new design and manufacturing system that reduces the length of metal bellows as much as 90 percent, while retaining original spring rate and stroke. The new bellows, named "Formset," were developed to fill the need for precision metal bellows in miniaturized components.

One of the first uses for the flattened bellows was as an expansion chamber in a liquid filled, hermetically sealed control system. The Formset bellows conserved space and helped to reduce the volume of liquid needed to fill the system. *Bridgeport Thermostat Division, Robertshaw-Fulton Controls Company.*

Circle number (91) on reply card.

Dual-Range Flowmeters. A complete new line of dual-range flowmeters is now being marketed by Air Reduction Sales Company. Known as the 1600 Series, they are designed for inert-gas welding, flushing molden metals, laboratory service, and many other industrial applications where accurate control and constant visual check of flow rate are required.

Flow ranges of the new flowmeters are sufficiently wide to meet gas demands formerly requiring more than one metering device. Rapid in-service switching from either flow range to the other is done by means of a piston-type selector valve. Flow rate within either range is controlled by a sensitive needle valve. *Air Reduction Sales Company, Division of Air Reduction Company, Incorporated.*

Circle number (92) on reply card.

Motor Base Reduces Down Time. Lost production due to stretched and sagging belts can be virtually eliminated by the American Pulley Company's Adjusto-Slide Motor Base. With this base, belt take-up is accomplished by adjusting only one screw. Replacement of belts is just as simple, for the adjusting screw can be loosened and swung aside, freeing the top plate and the motor to move far enough for installing the new belt. Once the new belt is in place, the motor is moved back in place, the adjusting screw swung back and tightened. *American Pulley Company, Power-Transmission Division.*

Circle number (93) on reply card.

Diaphragm Construction Pump. Rice Pump & Machine has introduced a new line of lightweight diaphragm pumps. The pumps are completely new in diaphragm pump design. Seed reduction from engine to pump is accomplished in one step by means of a worm gear drive. This drive eliminates intermediate speed reducers on engines and motors.

This new line is available with suction accumulators and swing type valves as shown or with ball check valves. Particular attention has been devoted to improved valve design and control of interior velocities to prevent clogging under adverse conditions. *Rice Pump & Machine Company.*

Circle number (94) on reply card.

Level Indicating Equipment. The JSP level measuring equipment is never in contact with the process material, and cannot be affected by corrosive liquids. It is easily installed on the outside of pipe without drilling of holes or welding of brackets.

Following several years of outstanding performance by this type of equipment on Government projects, the JSP-173A is now available to private industry. It provides positive means of recording and controlling the level of any process material from water or distillates to a slurry of finely crushed ore, over a wide range, from 6 to 48 in. Recording and controlling devices can be located up to 2000 ft from the point of actual measurement so that a battery of recorders or controllers may be located at one central control room to control process material levels at several remote gaging points. *Instruments, Inc.*

Circle number (95) on reply card.

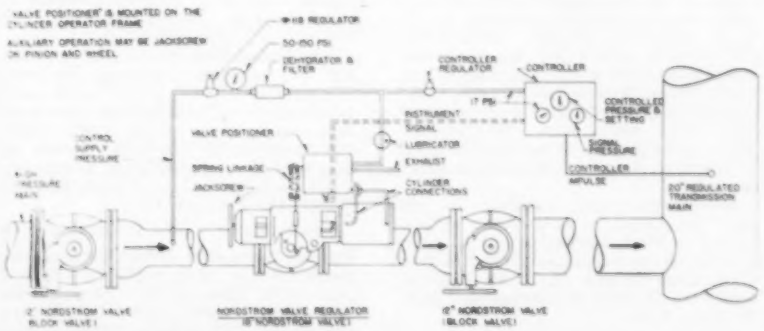
Arc Welding News. Volume XIV, No. 2, Hobart Arc Welding News, a 28-page booklet of interesting photographs and articles on welding from all over the world, is now available. Copies are mailed free of charge to anyone interested in welding. Articles feature time and money saving applications. *Hobart Brothers Co.*

Circle number (96) on reply card.

Tape Wrapping Machine. Lightweight, compact and durable, fast and easy to operate, Plicoflex "Speedmaster" tape wrapping machines provide the precise controlled performance so necessary to the application of tape on pipelines. Special features include: The ironing action of the wide wheels which insure the best possible tape bond; fully controllable tape overlap adjustment while in motion, and completely adjustable tension tape heads.

A 4-page illustrated brochure giving specifications and construction details on the 2-power operated models and the 3 manually operated models is available. *Plicoflex, Inc.*

Circle number (97) on reply card.



Valve-Regulator for High Pressure Gas Pipelines. A pneumatically controlled, cylinder-operated lubricated plug valve regulator, designed to provide high-pressure gas regulation with minimum pressure loss, has been developed by Rockwell. Advantages of the new unit include operational ease and favorable flow characteristics of the lubricated plug valve, high capacity with low pressure loss, silent regulation and automatic pressure control.

While the valve-regulator is effective on services such as intermediate pressure control, back pressure relief, and widely varying flows, it is primarily designed for high-pressure, large-volume applications. Typical installations include high-pressure transmission lines, storage and town border stations. *Rockwell Manufacturing Company.*

Circle number (98) on reply card.

NEW LITERATURE

Operators for Rockwell-Nordstrom Valves. A complete line of Westinghouse Air Brake power operators for actuating Rockwell-Nordstrom screwed-gland type, wrench-operated valves is cataloged in a new 4-page bulletin (V-604).

The operators are described as consisting of a cylinder, mounting bracket, radius arm and clevis bracket. They are mounted easily on the valve cover and can be operated with water, oil, gas or air at pressures up to 200 psi. *Meter and Valve Division, Rockwell Manufacturing Company.*

Circle number (99) on reply card.

New Self-Contained Controls Catalog. Automatic "package" controls, suitable for virtually any industrial application where a chemical or mechanical function can be measured electrically, are described in a 16-page catalog. Applications of Tipp-Tronic units specifically discussed in the catalog include control of temperature, torque, viscosity, current, voltage, timing of welding, conveyor overload, speed, plating, battery charging, radiation, moisture content, pressure, deflection, thickness, weight, color and light. *Tipp-Tronic, Inc.*

Circle number (100) on reply card.

Mixing Results. Can now be guaranteed for *any* process requirements, according to IPE's procedure for selecting its side-entering agitators. The number and size of units, and how they should be positioned, are derived from the basic process data; and performance is guaranteed by the manufacturer.

This point is featured in a new, 8-page brochure published by Industrial Process Engineers. Also included are the mechanical design details of their latest model side-entering agitators, a table of standard sizes and dimensions, and an outline of the supplementary information that is supplied with each installation. *Industrial Process Engineers.*

Circle number (101) on reply card.

Thermostatic Steam Traps. The new line of Anderson Quick-Flex Thermostatic Steam Traps for all outdoor and non-freeze service is described in a 4-page, 2-color bulletin recently published by the V. D. Anderson Company. Bulletin No. 257 itemizes typical uses for these new style steam traps which are designed primarily for outdoor service where a freezer-proof trap is required such as tracer lines, meter boxes, drips and other outdoor steam processing equipment found in chemical, refinery, and other outdoor operations.

Specifications and capacities for the traps are given in table form, accompanied by dimensional drawings. A piping diagram shows the recommended method of installing the trap. *The V. D. Anderson Company, Division of International Basic Economy Corp.*

Circle number (102) on reply card.

Diesel, Gas, Dual Fuel Catalog. Nordberg's line of 4-cycle diesel, duafuel and spark ignition gas engines are thoroughly described in a newly published 16-page bulletin, No. 257. The engines are built as supercharged; supercharged and intercooled; and Supairthermal units.

The in-line engines are built with either 6 or 8 cylinders and range from 640 to 2150 hp. Separate data sheets give horsepower ratings, outline drawings of the engines, and all dimensions which are required for preliminary planning.

The Supairthermal system which gives Nordberg engines higher horsepower output without increasing peak temperatures is explained and a schematic diagram illustrates the Supairthermal cycle of operation. *Nordberg Manufacturing Company.*

Circle number (103) on reply card.

New Digital Voltmeter Application and Data Booklet. Non-Linear Systems, Inc. announces the availability of a new 28-page booklet which describes the company's full line of digital voltmeters, digital ohmmeters, ac-dc converters, and complete data logging systems. *Non-Linear Systems, Inc.*

Circle number (104) on reply card.

Steel Tubing Tolerances. Peter A. Frasse & Co., Inc. has completed a new data chart which fully explains tolerances for steel tubing and pipe. Covered on one convenient chart are tolerances for *both* seamless and welded mechanical tubing, and seamless and welded stainless steel tubing and pipe. The chart clearly and comprehensively explains each tolerance in detail and gives the permissible variations in OD, ID, wall, ovality and straightness. *Peter A. Frasse & Co., Inc.*

Circle number (105) on reply card.

Basic Temperature, Pressure Controls. More than 34 basic types of industrial temperature and pressure controls are described in a new industrial catalog by the Powers Regulator Company. Included in the 96-page book are self-operating regulators, water mixing equipment, pneumatic control instruments, indicating and recording instruments, control valves, and pneumatic motors. The equipment described is designed for industrial process control, as well as for heating, ventilating, and air conditioning systems, and hot water service applications. *Powers Regulator Company.*

Circle number (106) on reply card.

Remote Positioning. Bulletin No. 1033, published by Copes-Vulcan Division, Blaw-Knox Company, describes pneumatic power drive units designed for the remote operation and positioning of valves, dampers, louvers, rheostats, vanes and variable-speed drives.

The 4-page bulletin explains the principle of operation including operating characteristics, and gives mechanical specifications. A table of sizes, torque ratings and weights, torque output curves and dimensional drawings provide all data needed to design these devices into a control system. *Copes-Vulcan Division, Blaw-Knox Company.*

Circle number (107) on reply card.

Pipeline Equipment Folder. International Harvester has made available a new 8-page folder showing the widespread use of the firm's crawler tractor line on pipeline construction projects. "Picture Proof of International Superior (Sideboom) Power" is exhibited in on-the-job photos showing the IH Superior-sideboom-equipped rigs working on various phases of the pipe-laying job-cycle. They are pictured stringing pipe, feeding bending machine, cradling pipe for cleaning-priming, wrapping and welding crews, and on the lowering-in operation. *Construction Equipment Division, International Harvester Co.*

Circle number (108) on reply card.

Small-Case Instrument Catalog. Fischer & Porter has published a catalog describing the company's new small-case instrument line for indicating, transmitting and controlling pressure and temperature. These instruments, to be called the Series 1450 line, are housed in fiber glass cases, making them particularly suitable for use outdoors or in corrosive atmospheres. Other features include wide temperature and pressure ranges and a variety of instrument controller options. *Fischer & Porter Co.*

Circle number (109) on reply card.

Selecting Pump Power. A new 12-page power selection handbook, "Selecting Power for Pumping," has been released by Caterpillar Tractor Co. Booklet is especially designed to be useful to those who have a pumping operation.

"Selecting Power for Pumping," contains a checklist of features necessary for continued dependable operation on pumping jobs. Step-by-step, the checklist describes the proper requirements which an engine must have, backing them with illustrations and examples of efficient installations. *Caterpillar Tractor Co.*

Circle number (110) on reply card.

Motor Starter, Contactor Bulletin. Allis-Chalmers complete line of motor starters and contactors in sizes 4, 5 and 6 (Type 425), 50 to 400 hp, is described in a new 12-page bulletin released by the company.

Designed to assure full rated capacity, maximum motor protection, longer life and easy maintenance, these starters and contactors have been applied to practically all types of drives including pumps, crushers, blowers, fans, screens and furnace controls. The contractors incorporate ACBO arc centering blowout, a modern principle of arc interruption which eliminates the need for conventional blowout coils. *Allis-Chalmers Manufacturing Company.*

Circle number (111) on reply card.

Automation. "Valves for Automation in the Steel Mills" is a new 16-page bulletin published by Golden-Anderson Valve. Each page schematically shows various piping and valve arrangements for particular applications, such as supply water from source to mill; emergency city connection; valves for liquid level control; emergency fire protection; spray valves for hot strip mills; coke quenching and drain valves; preventing flywheel explosion, and other mill uses. *Golden-Anderson Valve Specialty Company.*

Circle number (112) on reply card.

Protective Closures Catalog. Shurclose Seal Company has issued a new 4-page catalog on Shurclose caps and plugs. Complete specifications are given for both rubber and plastic closures for the protection, sealing or masking of threaded parts, pipe ends or tubing. Seven styles of stock sizes are covered by the specifications. *Sureclose Seal Company.*

Circle number (113) on reply card.

Propeller Fans Catalog. A revised catalog, Bulletin A-109C, covering their line of propeller fans, is published by the Hartzell Propeller Fan Company. It contains new fan sizes not shown in the previous edition as well as revised air deliveries, specifications, performance data and dimensional drawings on the entire line. Standard propeller, utility, cool-blast, Lo-Noise, reversible and Bi-Pass duct fans, intake air units and unit heaters are shown. *Hartzell Propeller Fan Company.*

Circle number (114) on reply card.

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